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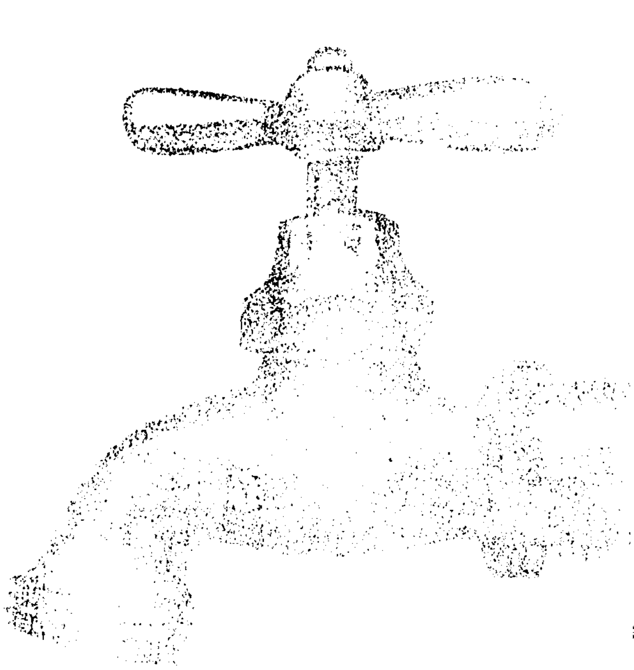

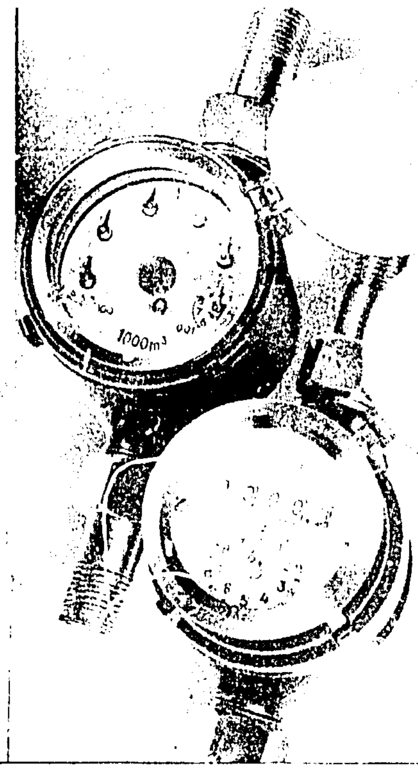

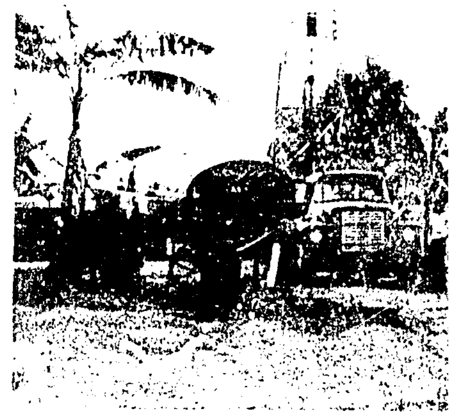

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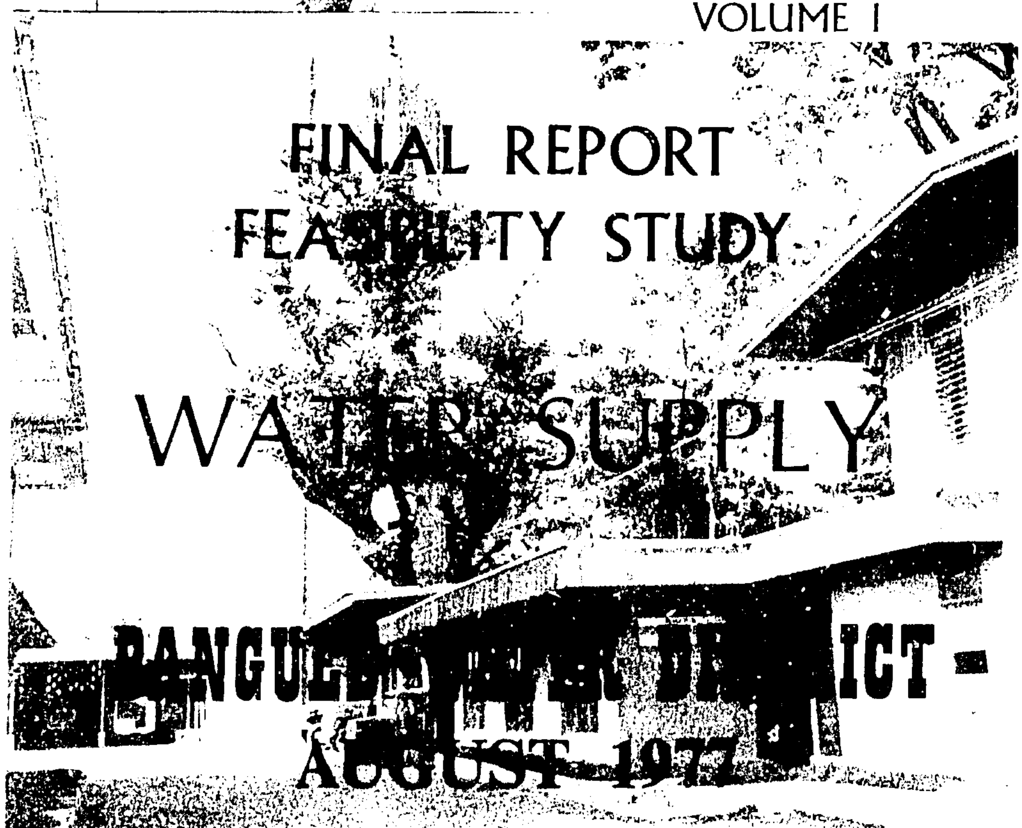
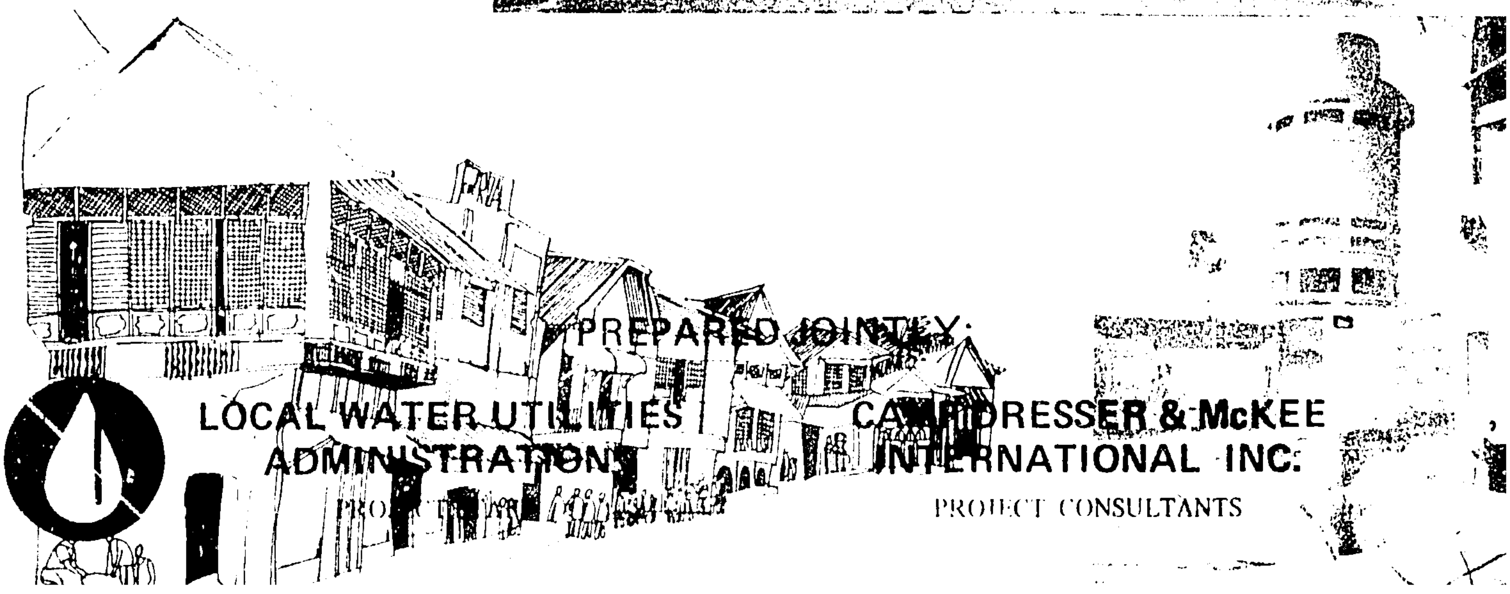


FINAL REPORT FEASIBILITY STUDY

WATER SUPPLY

BANGUED WATER DISTRICT - AUGUST 1977



PREPARED JOINTLY:

LOCAL WATER UTILITIES ADMINISTRATION
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26 August 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 - Bangued Water District (BAN-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 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.

Mr. Carlos C. Leaño, Jr.
General Manager
Local Water Utilities Administration
Re: Final Report - Feasibility Study
for Water Supply - Bangued Water
District (BAN-WD)

We wish to extend our thanks to the LWUA Board, all the members of the LWUA staff, the BAN-WD staff and the officials of various agencies of the Government of the Philippines, who so generously assisted us during the course of the 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 Bangued Water District (BAN-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 municipalities of Bangued and Peñarrubia in Abra 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 BAN-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 Sevilleja, Counterpart Chief Engineer
Rafael Luna, Group Leader
Delia Castañeda, Economist
Jean Casten, Economist
Lourdes Gutierrez, Technical Writer
Gelacio Bolante, BAN-WD General Manager
Severino Formoso, Former BAN-WD General Manager

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

Eduardo Santos, Staff Engineer
Miguel Buenavides, Junior Staff Engineer
Mario Bermejo, Junior Staff Engineer
Luisito Lacerna, Junior Staff Engineer
Cesar Matig-a, Chief Draftsman
Ellen Marcellana, Secretary/Typist
Meredith Maraño, Secretary/Typist
Cesar Florendo, Printing Assistant
Diosdado Burca, 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 Bangued Water District (BAN-WD) was formed on 29 December 1975 by virtue of Resolution No. 293 passed by the municipal council of Bangued. The BAN-WD includes portions of the neighboring municipalities of Bangued, the capital of Abra Province, and Peñarrubia. Following its formation, the BAN-WD acquired the ownership and management of the entire water system from the municipal government.

The municipalities of Bangued and Peñarrubia are situated in the northwestern portion of the Abra Province on the island of Luzon about 409 km north of Manila. Including their poblaciones, Bangued consists of 24 barrios with a total land area of 11,310 hectares; and Peñarrubia, 7 barrios with a total area of 3,660 hectares.

Bangued is located about 45 meters above mean sea level near the Abra River. Peñarrubia is located about 80 meters above mean sea level, 8 kilometers southeast of Bangued.

The combined population of the two municipalities in 1970 was 28,547, 60 percent of whom were classified as rural and 40 percent, urban. Their main source of income is agriculture.

Existing Water System

The water system of the BAN-WD was originally constructed in 1919, with major expansion in 1953. The source of water for BAN-WD is Lusuac Spring located at an elevation of about 200 meters above mean sea level. An impoundment and intake box convey the water to two transmission mains constructed between the spring and the poblacion of Bangued. The minimum measured overflow of Lusuac Spring was 18,000 cumd on 25 March 1977. Until 1953, hypochlorite was applied for water treatment at the spring site; at present, the spring water does not receive treatment.

There are two parallel transmission mains between Lusuac Spring and Bangued, a distance of about 8 km. The majority of both pipelines are 150 mm in diameter, with some short sections of 200 mm pipe. The first transmission main was constructed in 1919 and portions were repaired or replaced in 1953 when the second pipeline was constructed.

The storage facilities for BAN-WD consist of one 440-cum concrete storage tank located on Cassamata Hill south of the poblacion. The tank has some cracks and leaks.

The distribution system was first constructed in 1919 and expanded by 60 percent in 1951. The distribution pipes have a total length of 11.7 kilometers, of which 70 percent are galvanized iron, and the remaining 30 percent, cast iron.

Projections

The present service area of the BAN-WD covers only the poblaciones, and Barrio Lipcan in Bangued and Barrio Dumayco in Peñarrubia. The service area through the year 2000 will extend to the barrios of Dangdangla, Calaba, Bangbangar, Patucannay, Agtangao, Sao-atan and Palao in Bangued; and barrio Riang in Peñarrubia.

The population in the BAN-WD in 1975 was 18,443 and is projected to increase to 37,200 by 2000, for an average growth rate of 2.8 percent per year. During this same period, the population served by the BAN-WD is expected to increase from 6,720 to 30,020.

The per capita consumption of water is expected to be 178 lpcd in 1980 with a total average daily usage of 1,800 cumd. The per capita usage is projected to decrease to 174 lpcd in 1990 due to improved water accountability and then increase to 181 lpcd in 2000. The total average daily water usage is estimated to be 3,200 cumd in 1990 and 5,430 cumd in 2000.

Water Resources

Three potential sources of water, besides the Abra River, were identified for BAN-WD. Two sources were aquifers that would require wells to obtain water and the third source was springs, specifically Lusuac Spring.

One of the two aquifers is composed of Recent alluvium in the Abra River valley. This aquifer would be capable of producing water from wells and probably has adequate recharge from the Abra River.

The second aquifer is of older sediments that underlie the floodplain of the Abra River and the hills surrounding Bangued. This aquifer is generally less porous than the Recent alluvium and probably does not have adequate recharge to be able to support high-production wells.

Lusuac Spring emerges from a limestone formation, and from geologic studies of the area, the spring appears to be a result of solution channels in a large limestone formation. The formation would require massive amounts of recharge to maintain the spring flow; the dry and wet season fluctuations in flow would be significant. There is apparently sufficient flow at the present time to supply the water requirements of BAN-WD; however, careful monitoring of the spring discharge will be required to more accurately determine the minimum flow that may be expected.

Alternative Studies

Studies on alternative sources of water supply for BAN-WD indicate that continued use of Lusuac Spring would be the most economical over the project planning period. Surface water supplies from the Abra River and groundwater supplies were found not cost effective for BAN-WD.

The requirements for the distribution system were analysed with the aid of a computer and the resulting system is included in detail in Chapter IX. Based on the analysis of the pressure requirements of the system, two pressure service areas should be provided for BAN-WD. Peñarrubia and the adjacent barrios would be served directly from the transmission main through a pressure-reducing valve. The remainder of the BAN-WD would operate off the hydraulic grade line maintained by the storage tank.

Alternate transmission main routes were studied and all future transmission mains should follow the existing route for cost and hydraulic considerations.

B. RECOMMENDATIONS

General

A water supply system utilizing Lusuac Spring as the source of water through the year 2000 is recommended for BAN-WD. Improvements at the spring site in combination with new transmission, distribution and administrative facilities will be constructed 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 BAN-WD are summarized on Table I-1 and shown on Figure IX-1 (appended).

Source

Lusuac Spring will supply maximum-day demands of 6,500 cumd to BAN-WD in the year 2000. The existing facilities will be upgraded during Phase I-A to provide better collection and chlorination facilities. The upgraded facilities will not require any other expansion during the project period, however, chlorination capacity will be added as demand increases.

The BAN-WD will also be required to file an application with the National Water Resources Council to secure water rights at Lusuac Spring.

Transmission/Distribution Facilities

The transmission system between Lusuac Spring and Bangued will be improved in two phases. One 200-mm transmission pipeline will be constructed during Phase I-A, and a second identical pipeline constructed in Phase II-B.

TABLE I-1

SUMMARY OF PROPOSED WATER SUPPLY IMPROVEMENTS
BANGUED WATER DISTRICT

	Immediate Improvement Program	Construction Phase			
		I-A	I-B	II-A	II-B
Construction Period	1978-1979	1980-1985	1986-1990	1991-1995	1996-2000
Total Project Cost (₱ x 1000)	3,510	7,245	2,315	6,117	1,565
Foreign Exchange Component (₱ x 1000)1/	1,743	3,578	1,157	2,873	821
Source Development	Obtain legal water rights, add chlorination equipment	Construct new intake facilities	-	New meter	-
Transmission	Leakage survey and repair	New 200 mm pipeline - 7.9 km	-	New 200 mm pipeline - 7.9 km	-
Distribution	Leakage survey and repair,(See Page IX-3)100 mm-2.9 km 150 mm-1.2 km 200 mm-1.4 km 250 mm-0.6 km	See Table IX-2 100 mm-0.4 km 150 mm-6.0 km 200 mm-.3km	See Table IX-4 100 mm-2.6 km 150 mm-2.4 km	See Table IX-6 100 mm-0.8km 150 mm-0.3 km 200 mm-0.9 km	-
Storage	Repair existing 440 cum tank	-	-	New 200 cum tank	-
Internal Network	Leakage survey and repair	88 ha	54 ha	34 ha	51 ha
Service Connections	Repair 260 Add 234	Add 605	Add 606	Add 879	Add 880

TABLE I-1 (Continued)

	Immediate Improvement Program	Construction Phase I-A	I-B	II-A	II-B
Hydrants	Repair existing hydrants	60 ha	55 ha	63 ha	63 ha
Miscellaneous	Administrative facilities and equipment, plumbing shop space, vehicles	Plumbing Shop with meter test/ repair			

1/ 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 RP pesos at a rate of U.S.$1.0 = RP ₱7.00. 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.

The distribution system will be reinforced and expanded by constructing 26 km of pipelines with sizes from 100 to 200 mm, by 1990. An additional 10 km of pipelines will be constructed by the year 2000 to extend water service to more consumers.

By 2000, approximately 227 hectares within BAN-WD will receive internal network pipelines and 3,464 new service connections will be added. All existing and new services in the district will be metered.

Storage

The existing 440-cum distribution storage tank will be adequate for BAN-WD through Phase I-B. The tank will have to be repaired during the immediate improvement program to eliminate leakage. A 200-cum storage tank will be constructed during Phase II-A in order to meet the distribution storage requirements to the year 2000.

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.

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 the 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 BAN-WD householder.

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

	Rate/RU
1978-1980	₱0.70
1981-1983	1.20
1984-1986	1.60
1987-1989	1.80
1990	1.90

TABLE I-2

CAPITAL COST SUMMARY

Construction Phase	Construction Period	Construction Cost (₱)	Project Cost (₱) Local	FEC	Total
Immediate Improvement Program	1977-79	2,708,100	1,766,400	1,743,300	3,509,700
I-A	1980-85	5,850,800	3,667,600	3,577,700	7,245,300
I-B	1986-90	1,929,700	1,157,800	1,157,200	2,315,000
II-A	1991-95	4,922,400	3,243,600	2,873,000	6,116,600
II-B	1996-2000	1,354,600	743,400	821,200	1,564,600
Total		16,765,600	10,578,800	10,172,400	20,751,200

TABLE I-3

COST SUMMARY OF IMMEDIATE IMPROVEMENT
PROGRAM AND CONSTRUCTION
STAGE I PHASE A
Cost (₱ x 1000)

Item	Local	Foreign*	Total
Immediate Improvement Program			
Distribution Facilities			
Leakage Detection and Repair	23,000	94,000	117,000
Distribution System Pipelines	620,000	621,000	1,241,000
Disinfection Facilities	10,800	21,500	32,300
Storage Facilities			
Repair Existing Tank	12,500	16,000	28,500
Service Connections			
Installation, Conversion and Repair	283,900	480,400	764,300

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*US $1.00 = ₱7.00

TABLE I-3 (continued)

	Local	Foreign	Total
Administrative and Miscellaneous			
Administrative Building and Equipment	383,000	69,000	452,000
Vehicles	30,000	30,000	60,000
Miscellaneous	5,000	8,000	13,000
Total Construction Cost	1,368,200	1,339,900	2,708,100
Contingencies	205,200	201,000	406,200
Engineering	109,000	202,400	311,400
Land Costs	84,000	-	84,000
TOTAL PROJECT COST	1,766,400	1,743,300	3,509,700
Stage 1 Phase A Construction			
Source Development	87,600	116,000	203,600
Pipelines and Valves	1,566,300	1,598,100	3,164,400
Laboratory Facilities	139,900	274,000	413,900
Meter Repair Facilities	59,400	55,600	115,000
Plumbing Shop	363,000	-	363,000
Internal Network	515,000	370,400	885,400
Service Connections	212,700	293,300	506,000
Fire Hydrants	58,600	80,900	139,500
Vehicle	30,000	30,000	60,000
Total Construction Cost	3,032,500	2,818,300	5,850,500
Contingencies	414,000	384,100	798,100
Engineering	202,100	375,300	577,400
Land Costs	19,000	-	19,000
TOTAL PROJECT COST	3,667,600	3,577,700	7,245,300

TABLE I-4

ANNUAL OPERATION AND MAINTENANCE COSTS (₱)

Item	1976	1980	1990	2000
Administration and Personnel	36,300	100,200	185,900	238,600
Power and Fuel	-	13,200	13,200	13,200
Chemicals	1,100	6,600	13,100	22,000
Maintenance	7,300	24,300	63,900	97,700
Miscellaneous	4,400	5,300	13,700	35,500
Total	49,000	149,600	289,800	407,000

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	₱0.85
from 17 to 24 cum	1.70
greater than 24 cum	2.70

Borrowing requirements will include ₱4.207 million from 1978 to 1981 for the immediate improvement program; ₱9.834 million from 1980 to 1985 for Phase I-A improvements; and ₱3.888 million from 1985 to 1990 for Phase I-B improvements.

Economic Feasibility

The recommended improvements to the BAN-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 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. Analysis shows a benefit-cost ratio of 1.14:1 and an IERR of 15.8 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 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).

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.

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 are Urdaneta, Gapan, Calamba, Bislig, Silay City, Bangued, Baybay, Roxas City, 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 Bangued Abra.

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:5/

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 BANGUED WATER DISTRICT

The BAN-WD was formed on 29 December 1975 by virtue of Resolution No. 293 passed by the Sangguniang Bayan (municipal council) of Bangued. The district includes portions of the neighboring municipalities of Bangued and Peñarrubia - the poblacion6/ and the barrios7/

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

5/Refer to Appendix A, Volume II for complete Terms of Reference.

6/Town proper.

7/A barrio is a political division of a city or municipality.

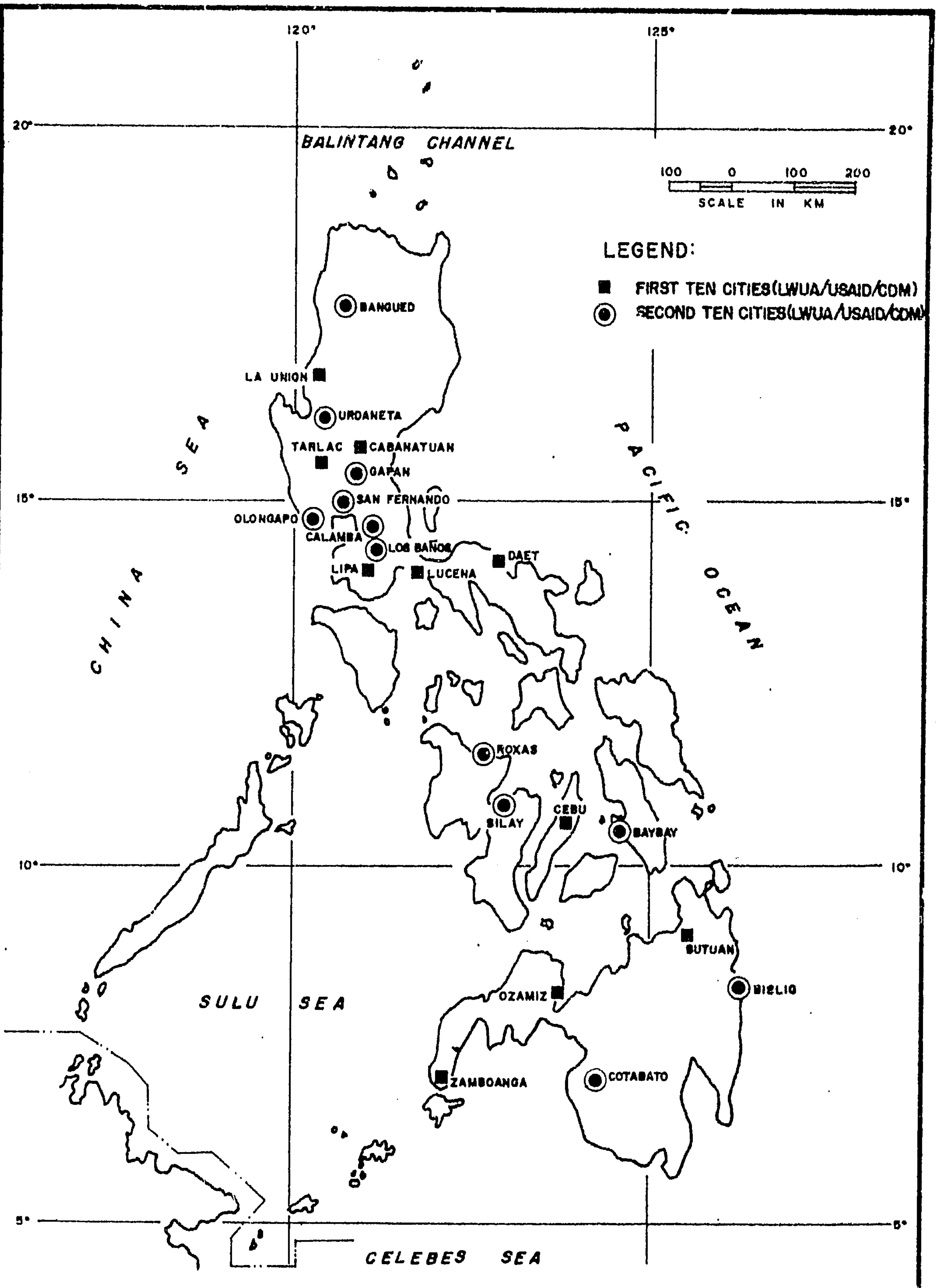

FIGURE II-1
LOCATION MAP
REPUBLIC OF THE PHILIPPINES

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

of Lipcan, Dangdangla, Calaba, Bangbangar, Patucannay, Agtañgao, Sao-atan and Palao in Bangued; and the poblacion and barrios Dumayco and Riang in Peñarrubia. The formation of the BAN-WD was prompted primarily by the need for an upgraded water supply system. Limited funding prevented substantial improvements to the system. Moreover, the local officials recognized the potential role of the water district in providing sufficient, safe and potable water supply.

The existing water system of Bangued was constructed in 1919 by the Bureau of Public Works and managed by the municipal government. In 1956, the National Waterworks and Sewerage Authority (currently the Metropolitan Waterworks and Sewerage System) took over the system which, however, reverted to the municipal government in 1963. Following its formation, the BAN-WD acquired the owne ship and management of the entire system in accordance with Presidential Decree (PD) No. 198 (The Provincial Water Utilities Act of 1973).

The BAN-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 BAN-WD can obtain financial and technical assistance from LWUA. PD No. 198 provides that the water district operate eventually on a financially self-sufficient basis.

... BAN-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 BAN-WD can promulgate its own operating laws through its 5-member board of directors, appointed by the municipal mayor. The district can only be dissolved through the act of this board.

On 24 August 1976, LWUA awarded a Conditional Certificate of Conformance to the BAN-WD after it had complied with the minimum requirements of LWUA's certification program. This certificate entitles the BAN-WD to rights and privileges authorized under PD No. 198.

CHAPTER III DESCRIPTION OF THE WATER DISTRICT[1]

A. PHYSICAL DESCRIPTION

Location

The neighboring municipalities of Bangued and Peñarrubia are situated in the northwestern portion of Abra province[2] on the island of Luzon. Bangued, the capital of Abra, borders along the province of Ilocos Sur; Peñarrubia is an inland municipality southeast of Bangued. The areas are 11,310 hectares for Bangued and 3,660 hectares for Peñarrubia.

Including their poblaciones, Bangued has 24 barrios, and Peñarrubia, 7 barrios. However, the present service area[3] of the BAN-WD covers only the poblaciones, and Barrio Lipcan in Bangued and Barrio Dumayco in Peñarrubia. The service area in the year 2000 will include the barrios of Dangdangla, Calaba, Bangbangar, Patucannay, Agtañgao, Sao-atan and Palao in Bangued; and barrio Riang in Peñarrubia. (See Figures III-1 and VI-1).

Physical Features

Highlands account for nearly half of the total area of Bangued and Peñarrubia. The lowland areas in the valley of the Abra River are generally under cultivation. Elevations in Bangued poblacion range from 40 to 50 meters above mean sea level; in Peñarrubia poblacion, 70 to 90 meters above mean sea level.

The Abra River is the most important body of water in the province. With headwaters southeast of the province, the river drains the northern barrios of Bangued and flows southwestward through Ilocos Sur to the China Sea. Sinalang and San Matias Rivers, both emptying into Abra River, drain the southern and eastern portions of Bangued.

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[1] While the BAN-WD is limited to portions of Bangued and Peñarrubia, the municipalities are described herein in their entirety.

[2] Abra is an inland mountainous province located in the western side of the Cordillera mountains in the Ilocos Region. The boundaries include the provinces of Ilocos Norte and Kalinga-Apayao on the north; Ilocos Sur on the west and south; Mountain Province on the south; and Kalinga-Apayao on the east.

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

Bangued and Peñarrubia are classified under the Type 1 climate, with 2 pronounced seasons (Figure III-2). The dry season extends from October to April; the rainy season occurs during the rest of the year. The average annual rainfall for the period 1960-69 was 2,697 mm. For the same years, temperature ranged from 25.4°C in January to 28.4°C in May, with the average at 26.9°C. The climatological data are listed in Table III-1.

TABLE III-1

CLIMATOLOGICAL DATA[4/]
(1960-69)

	Rainfall (mm)	Temperature (°C)
January	0.3	25.4
February	0.4	25.7
March	12.0	26.4
April	22.0	27.9
May	158.4	28.4
June	454.5	27.4
July	616.1	27.3
August	802.9	27.0
September	499.2	27.0
October	97.0	27.0
November	25.6	27.4
December	8.7	26.1
Total	2,697.1	
Average		26.9

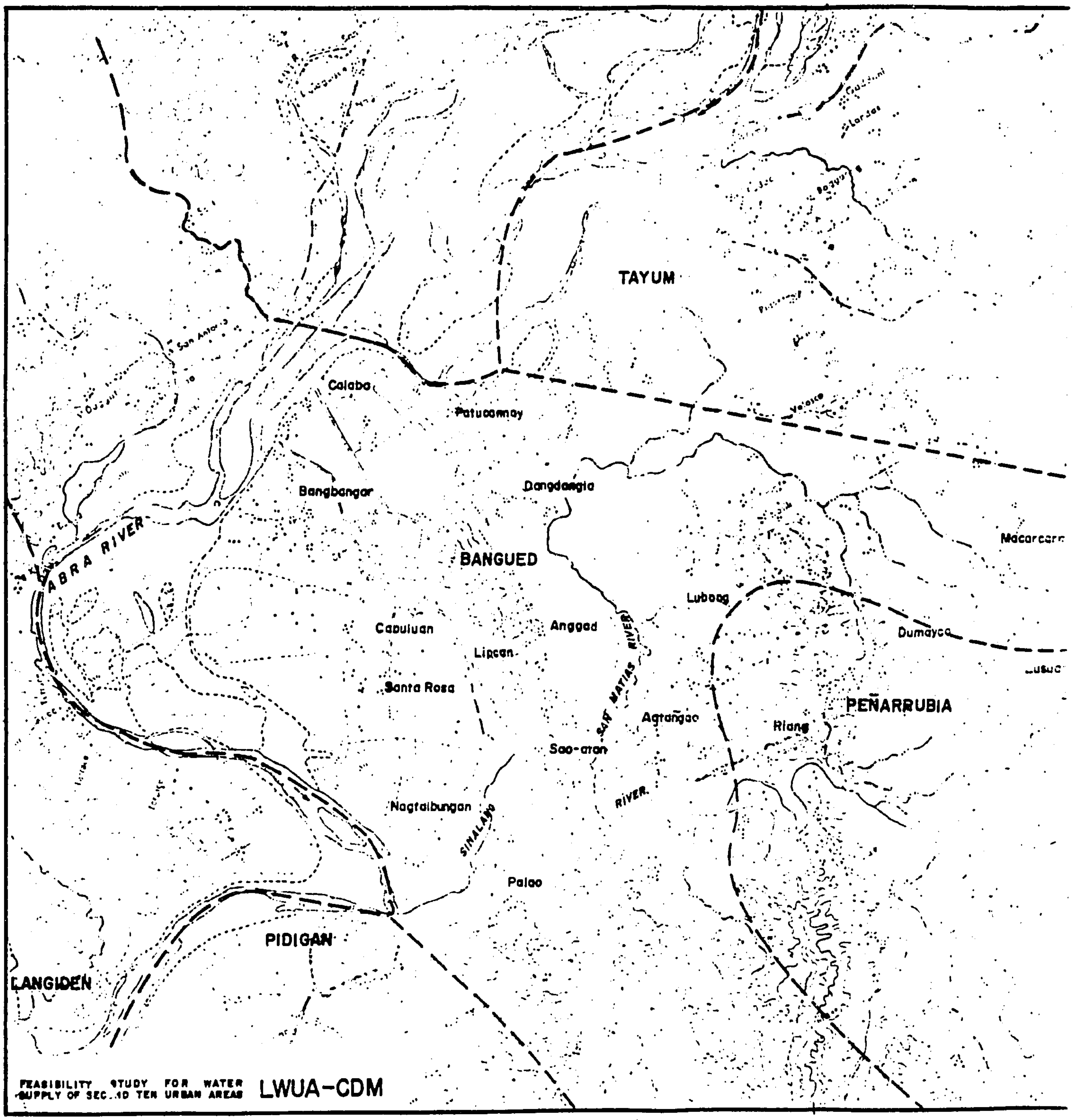
B. POPULATION

The combined population of Bangued and Peñarrubia in 1970 was 28,542, an increase of 27 percent over the 1960 total of 22,488. The two municipalities had a total of 4,890 households, or an average of 5.8 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 Bangued and Peñarrubia are listed in Table III-3. These indicators include types of dwelling units, household facilities and utilities.

[4/] Source: PAGASA Station in Vigan, Ilocos Sur



FEASIBILITY STUDY FOR WATER SUPPLY OF SEC..ND TEN URBAN AREAS LWUA-CDM

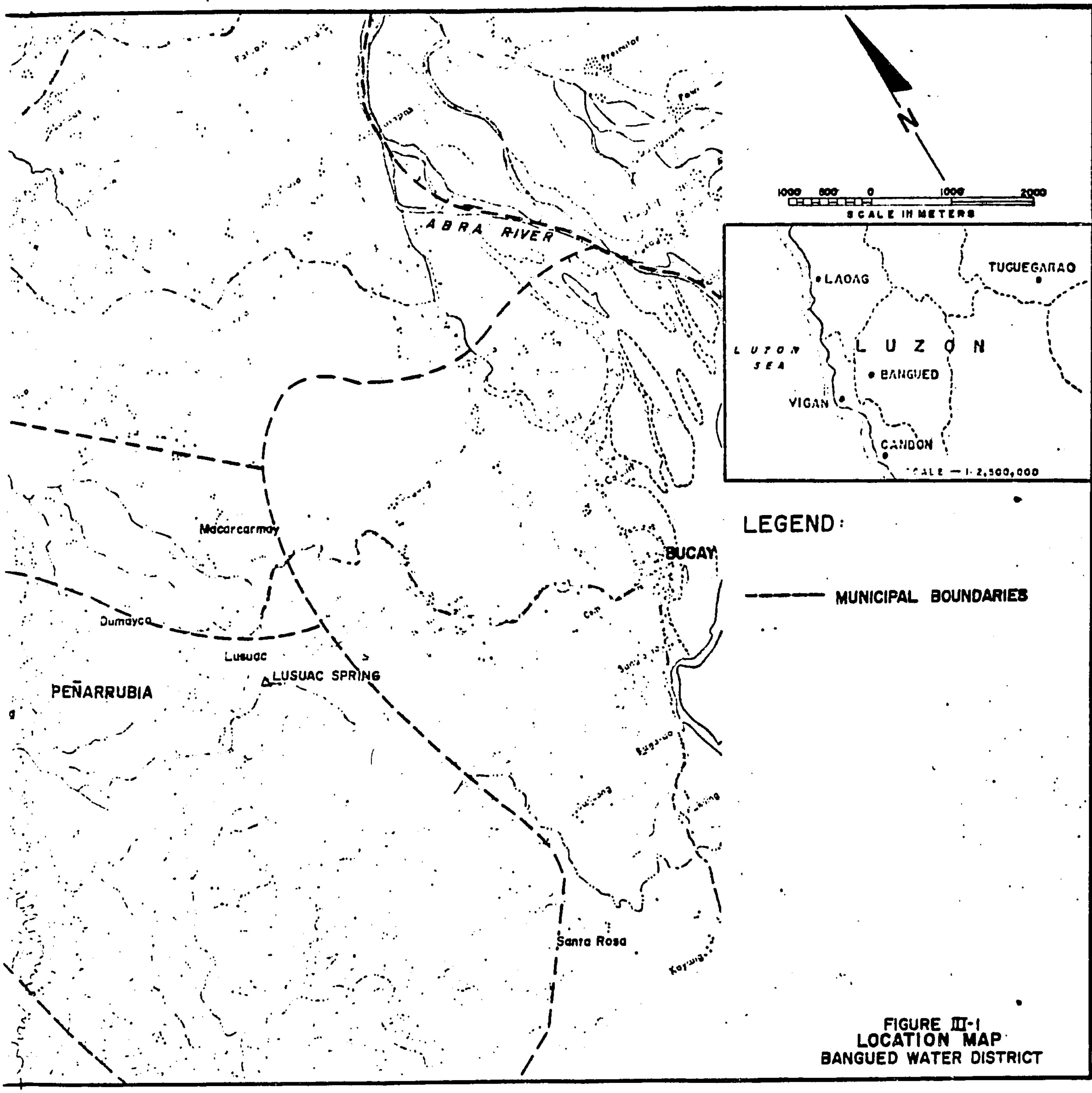


FIGURE III-1
LOCATION MAP
BANGUED WATER DISTRICT

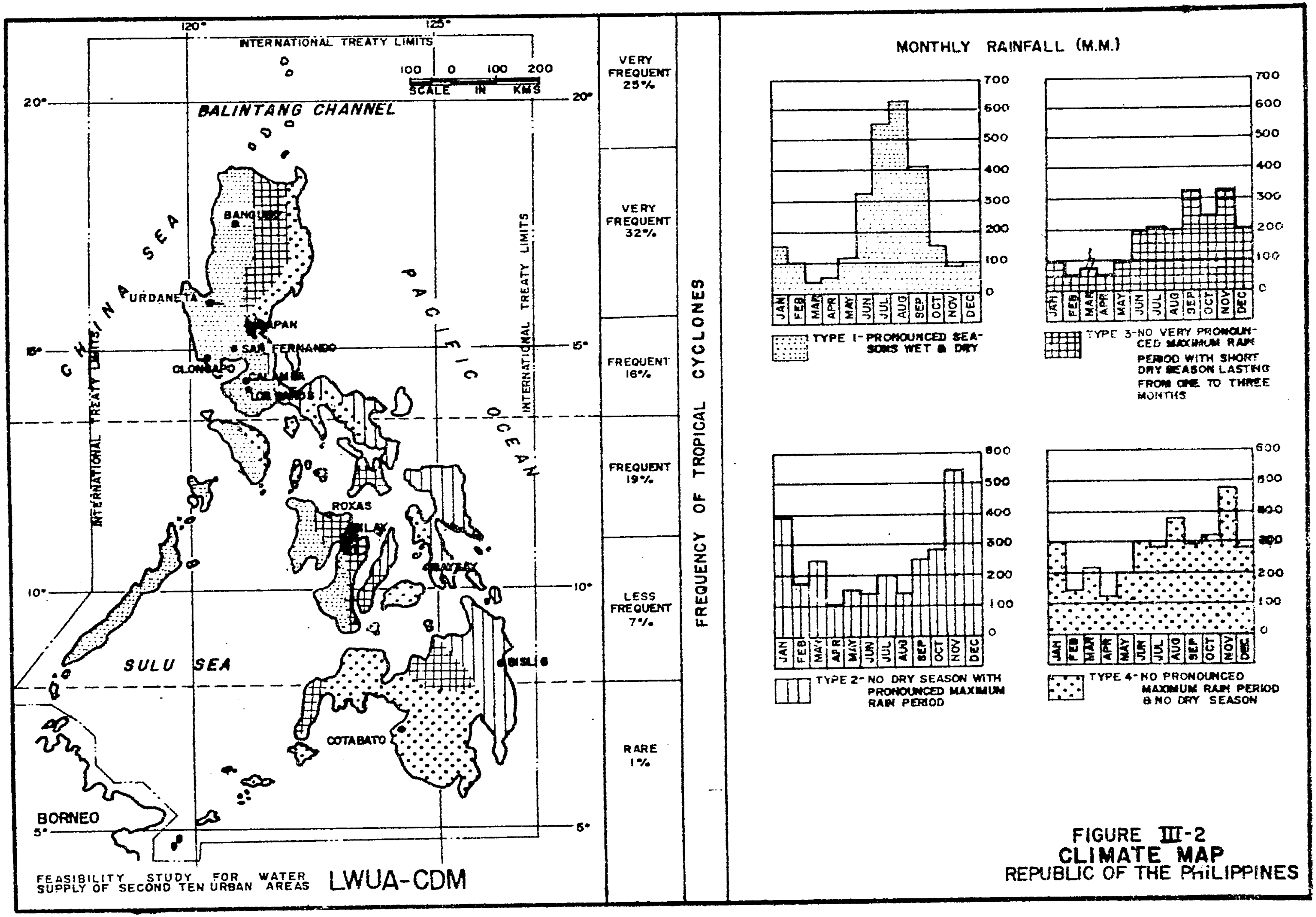


FIGURE III-2
CLIMATE MAP
REPUBLIC OF THE PHILIPPINES

TABLE III-2

MUNICIPAL POPULATION CHARACTERISTICS[5] (1970)

	Bangued	Peñarrubia
1. Total Population	24,587	3,955
2. Growth Rate (1960-70)	2.4% per annum	2.4% per annum
3. Density	2.2 persons per hectare	1.1 persons per hectare
4. Urban/Rural	urban, 40% rural, 60%	totally rural
5. Sex Composition	male, 48% female, 52%	male, 48% female, 52%
6. Age Composition	0-14 years, 41%; 15-64 years, 53%; 65 years and over, 6%	0-14 years, 41%; 15-64 years, 53%; 65 years and above, 6%
7. Employment (% of those 10 years and over)	(10 years and over, 17,208); employed, 47%; unemployed, 53%	(10 years and over, 2,945); employed, 53%; unemployed, 47%
a) By class of worker (% of labor force)	wage and salary, 42%; own business, 37% unpaid family workers, 21%	wage and salary, 28%; own business, 39%; unpaid family workers, 33%
b) By industry (% of labor force)	agriculture, forestry and fishing, 45%; manufacturing, 9%; services, 31%; commerce, 6%; construction and other industries, 9%	agriculture, forestry and fishing, 67%; manufacturing, 3%; services, 14%; commerce, 3%; construction, 2%; utilities and other industries, 11%
8. Education (% of those 6 years and over)	(6 years and over, 20,298); literate, 82%; illiterate, 18%	(6 years and over, 3,390); literate, 70%; illiterate, 30%
a) By attainment (% of those 25 years and over)	(25 years and over, 9,491); elementary grades, 52%; high school, 18%; college, 15%; no formal education, 15%	(25 years and over, 1,593); elementary grades, 57%; high school, 10% college, 7%; no formal education, 26%
9. Dialects	Ilocano, 98%; Tagalog and others, 2%	Ilocano, 64%; Tinggian, 35%; others, 1%
10. Religion	Catholic, 98%; others, 2%	Catholic, 88%; Protestant, 3%; others, 9%

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

These data apply to the municipalities of Bangued and Peñarrubia as a whole.

TABLE III-3

CLASSIFICATION OF HOUSEHOLDS BY TYPE OF FACILITIES[6] (1970)

	Bangued	Peñarrubia
1. Total Households	4,223	665
2. Average Household Size	5.8 members per household	5.9 members per household
3. Water Facilities (% of total households)	piped water, 46%; artesian well, 22% pump, 12%; open well, 18%; spring, 2%	artesian well, 20%; pumps, 53%; open well, 15%; spring, 12%
4. Toilet Facilities (% of total households)	flush/water sealed 20%; closed pit, 41%; open pit, 19%; public toilet, 1%; no facilities, 19%	flush/water sealed, 6%; closed pit, 45%; open pit, 12%; no facilities, 37%
5. Solid Waste Disposal System	About 30 cumd of solid wastes is collected by the municipal government. These wastes are dumped and buried in an area near the Abra River northwest of the poblacion.	Peñarrubia has no solid wastes collection system. Households usually burn the wastes in their yards.
6. Lighting Facilities (% of total households)	electricity, 23% kerosene, 76%; other sources, 1%	kerosene, 100%
7. Appliances (% of total households)	radio, 55%; TV, 2%; refrigerator, 4%	radio, 33%; TV, 1%; refrigerator, 6%
8. Cooking Fuel (% of total households)	wood, 87%; LPG, 7%; kerosene, 5%; electricity and other fuel, 1%	wood, 98%; kerosene, 1%; LPG, 1%
9. Total Dwelling Units	4,019	659
a) Type of dwelling unit (% of total units)	single type, 95%; the remaining 5% includes duplex apartment/accessoria, commercial, etc.	single type, 98%; barong-barong (makeshift houses), 2%
b) Roofing material (% of total units)	aluminum/galvanized iron, 75%; cogon, 23%; tile/concrete and nipa, 1%	aluminum/galvanized iron, 58%; cogon, 41%; nipa and others, 1%

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[6] Source: 1970 Census of Population and Housing, NCSO
These data apply to the municipalities of Bangued and Peñarrubia as a whole.

Health

Water-borne diseases occur particularly in the more densely populated sections of the municipality. 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 the province of Abra[7] from 1964 to 1974. During this period, the average morbidity of 1,170.6 in this province was 1.75 times the national average of 666.5; the average mortality of 44.3 was lower than the national average of 48.1.

TABLE III-4

REPORTED MORBIDITY AND MORTALITY DUE TO WATER-BORNE DISEASES[8] (1964-74) (per 100,000 population)

Year	Abra		Philippines	
	Morbidity	Mortality	Morbidity	Mortality
1964	2,094.8	65.4	846.3	60.2
1965	1,166.4	33.6	715.8	51.6
1966	1,104.9	58.4	715.1	61.9
1967	1,023.1	35.4	572.1	47.6
1968	898.0	38.7	564.8	46.5
1969	1,209.6	28.7	706.9	46.0
1970	1,472.7	28.1	612.8	39.0
1971	1,192.7	25.8	422.5	35.8
1972	1,019.1	67.5	743.4	49.4
1973	848.0	59.5	768.4	50.4
1974	847.1	46.1	663.8	40.4
Total	12,876.4	487.2	7,331.9	528.8
Average	1,170.6	44.3	666.5	48.1

7/ The only records available are for the province. The morbidity and mortality trends in Bangued and Peñarrubia are assumed from these records (see Chapter XI).

8/ Source: Disease Intelligence Center, Department of Health.

The water-borne diseases, of which records are available, include typhoid, cholera, dysentery, and gastro-enteritis.

D. ECONOMY[9]

Family Income[10]

In 1971, the province of Abra was estimated to include 28,300 families, with a combined annual income of ₱83 million. The average family income of ₱2,933 was lower than the country's average of ₱3,736. About 85 percent of the families belonged to the low income (less than ₱500-₱2,999) bracket. The middle income (₱3,000-₱5,999) group constituted 13 percent. The remaining 2 percent received annual income of ₱6,000 and over.

Municipal Income

Based on its annual income, Bangued is classified as a third-class municipality. In fiscal year 1974-75, the total municipal income was about ₱670,000, over 50 percent of which was derived from government operations. Water bill collections comprised about 6 percent of the total income. Other sources were taxation (42 percent) and incidental revenues (7 percent).

Agriculture, Commerce and Industry

Agriculture is the major occupation and is concentrated in the Abra River valley. Tobacco and rice are the primary commercial crops.

In 1975, the total number of commercial and industrial establishments in Bangued was 522. Fifty-two (52) percent of the establishments were engaged in the wholesale, retail and food business and 11 percent, in manufacturing.

Cottage industries provide additional employment during the off-planting season. These include ceramics, pottery, hat weaving and basketry.

Public Utilities

Only land transportation is available in Bangued. As of September 1976, the number of public vehicles included 81 jeepneys, 80 buses 284 tricycles and 17 trucks.

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

[10] Only provincial data on family income are available at the NCSO.

Communication facilities consist of a telephone system, 2 telegraph stations and a post office.

The power requirements of Bangued and other neighboring municipalities are supplied by the Abra Electric Cooperative Incorporated (ABRECO) which is under the supervision of the National Electrification Administration. ABRECO has a study that includes projection of power supply requirements to 1983. It currently obtains electric supply from the National Power Corporation (NPC) with a maximum transporting capacity of 20 mega volts-ampere (MVA). However, present consumption only requires 5 MVA.

Consumers are classified into domestic, commercial, industrial and public buildings. Power rates vary in each category according to the number of kilowatt-hours consumed plus the cost of fuel adjustment based on NPC's billing to ABRECO. In this study, the water district is classified as a commercial user charged ₱0.33/kwh used. However, the rate of ₱0.41/kwh has been used in the comparative analysis of costs with the difference attributed to the cost of fuel adjustment.

CHAPTER IV EXISTING WATER SUPPLY FACILITIES

A. GENERAL

The municipality of Bangued has been served by a waterworks system as early as 1919. In 1953, the system was expanded to serve the municipality of Peñarrubia and other barrios by adding a second transmission line from the spring source. Existing facilities include a spring impoundment and intake box, hypochlorination structure (abandoned), storage tank, transmission and distribution mains and other appurtenances. A schematic plan of the existing system is shown in Figure IV-1.

B. WATERWORKS FACILITIES

Source Facilities

The only source of water for BAN-WD is Lusuac Spring, about 8 km southeast of Bangued. It is located uphill in Barrio Lusuac, Peñarrubia at an elevation of about 200 meters above mean sea level. Source facilities include a spring impoundment and a trapezoidal intake box.

Spring Impoundment. The spring emerges from an artificial pool impounded by numerous porous rocks sealed with mud or concrete. The 300-sqm pool is uncovered and fenced with barbed wire, and leaks badly (see Figure IV-2). The spring overflows from the artificial pool over a weir made of wooden boards. It supplies a 150-mm line leading directly to Bangued and three 75 mm and one 200 mm pipes leading to an adjacent intake box. These intake pipes are provided with wire screens at the inlet end.

Intake Box. The existing intake box has an area of 9.28 sqm and an average height of 0.92 meter. It is a concrete trapezoidal box with an overflow elevation of about 0.72 meter above the ground supplying a valveless 150-mm pipe to a nearby swimming pool. This connection allows the backflow of water from the swimming pool, when the water level at the pool is greater than the water level at the intake. Such backflow could contaminate the water in the intake box and in the transmission line to the poblacion.

The minimum measured overflow and leakage from the spring and swimming pool is about 18,000 cumd. The discharge was measured with a staff gauge installed on 17 November 1976.

Treatment Facilities

The water supply to Bangued used to be treated with hypochlorite solution. However, treatment was stopped when the second transmission line was installed, bypassing the intake chamber. At present, the supply is not disinfected.

Transmission Mains

The first transmission main laid in 1919 consists of a combination of a 320-meter long, 200-mm CCI pipe and a 7,570-meter long, 150-mm CCI pipe. This line, which extends from the intake box to the storage tank, serves Bangued. In 1953, the 200 mm pipe was extended by 400 meters, replacing a portion of the original 150 mm pipe. In the same year, other portions of the 150 mm pipe were replaced with AC and GI 150-mm pipes but whose length and location are not known. Also in 1953, a second transmission main was laid, bypassing the intake box. This line, a 7,525-meter, 150 mm AC pipe, extends from the spring impoundment to the storage tank and serves both Bangued and Peñarrubia.

The 2 transmission lines converge into a single 365-meter long, 150 mm AC pipe leading to the storage tank and near the Bangued Poblacion, at an elevation of 55 meters above mean sea level. A CCI pipe is connected to the second transmission main before the junction of the 2 transmission mains. This pipe, 570 meters long and 100 mm in diameter, bypasses the storage tank and directly feeds the distribution system.

The total length of the transmission pipelines is 16.4 km. They are mostly made of centrifugally cast iron. Over 90 percent of the pipelines are 150 mm in diameter. A description of the transmission system by size, material and age is given as follows:

Size (m)	Type	Length of Pipe (m) 1919	1953-Present	Total
100	CCI		570	570
150	CCI, GI, AC	7,570	7,525	15,095
200	CCI	320	400	720
	Total	7,890	8,495	16,385

A plan and profile of the existing transmission lines is shown in Figure IV-3.

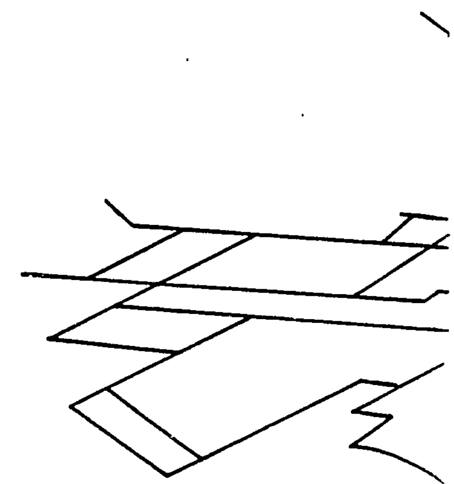
At the present time, the production of water for BAN-WD is limited by hydraulic conditions of the transmission main to about 2,600 cumd.

Storage

The only storage facility of BAN-WD was constructed in 1919 as part of the original system. It is located at Cassamata Hill south of the poblacion at an elevation of 101 meters. It has a total capacity of 440 cum and an overflow elevation of 101.6 meters

TRANSMISSION LINES

DIAMETER (MM)	TYPE	LENGTH (M) OF PIPE BY YEAR INSTALLED		REMARKS
		1919	1953	
100	CCI		570	BY-PASS THE RESERVOIR
150	AC,CCI,GI	7570	7525	SPRING TO RESERVOIR
200	CCI	320	400	SPRING TO RESERVOIR
TOTAL		7890	8495	



BANGUED POBLACION
ELEV. 40M ABOVE MSL

DISTRIBUTION SYSTEM

DIAMETER (MM)	TYPE	LENGTH (M) OF PIPE BY YEAR INSTALLED		TOTAL
		1919	1951 - 1976	
25	GI	350	1260	1610
50	GI		1565	1565
75	GI	5160		5160
100	CCI	640	2480	3120
150	CCI	240		240
TOTAL		6390	5305	11,695

DISTRIBUTION RESERVOIR (1919) —

- REINFORCED CONCRETE TRAPEZOIDAL ... GROUND RESERVOIR, COVERED
- CAPACITY = 440 CUM
- OVERFLOW ELEVATION = 101.6 M ABOVE ...

APPURTENANCES

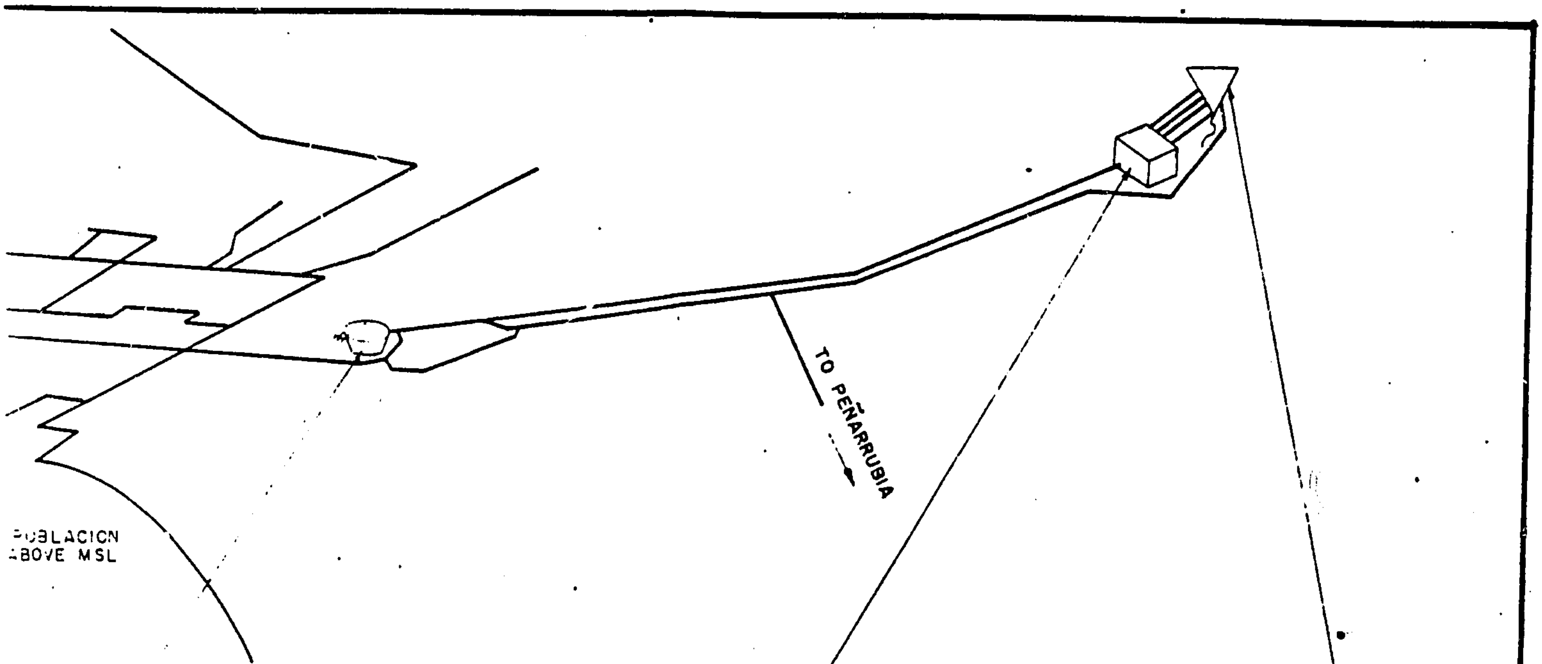
	SIZE	NUMBER	REMARKS
VALVES	75,100,150 MM	13	SOME ARE LOST, OTHERS INOPERABLE
HYDRANTS	75 MM FABRICATED	31	SEVERAL ARE LEAKING
PUBLIC FAUCET	12 MM	1	LOCATED IN THE PLAZA

TREATMENT

- NONE

SERVICE CONNECTION, SEPTEMBER 1976

TYPE	FLAT-RATE
DOMESTIC	825
COMMERCIAL	32
INSTITUTIONAL	11
TOTAL	868



INTAKE BOX (1919)
- REINFORCED CONCRETE TRAPEZOIDAL INTAKE BOX.
- COLLECTS WATER FROM THREE 75 MM AND A 200 MM PIPE FROM THE SPRING.
- A 150 MM PIPE TRANSMISSION MAIN BY-PASSES THE INTAKE BOX.

LUSUAC SPRING
- ELEVATION OF 202 M ABOVE MSL.
- UTILIZED CAPACITY OF 2600 CUMD (VISUAL)
- WATER IS IMPOUNDED BY ROCKS SEALED WITH MUD AND CONCRETE OPEN ON TOP AND FENCED WITH BARBED WIRE.
- MEASURED MINIMUM CAPACITY IS 18,000 CUMD.

SYSTEM PRESSURE

- MANY PARTS OF THE CITY HAVE VERY LOW/NO PRESSURE DURING DAYTIME ESPECIALLY IN EXTREMITIES OF THE DISTRIBUTION NETWORK.

SERVICE AREA OPERATION

- WATER FROM LUSUAC SPRING FLOWS INTO THE DISTRIBUTION NETWORK DURING AN 18 HOUR PERIOD.
- WATER IS FED TO THE DISTRIBUTION LINES FROM THE RESERVOIR FROM 0400 TO 0600 HOURS SIMULTANEOUSLY WITH THE SUPPLY COMING DIRECTLY FROM THE TRANSMISSION MAIN.
- THE RESERVOIR IS FILLED FROM 2100 TO 0300 HOURS.

FIGURE IV-1
EXISTING FACILITIES
BANGUED WATER DISTRICT

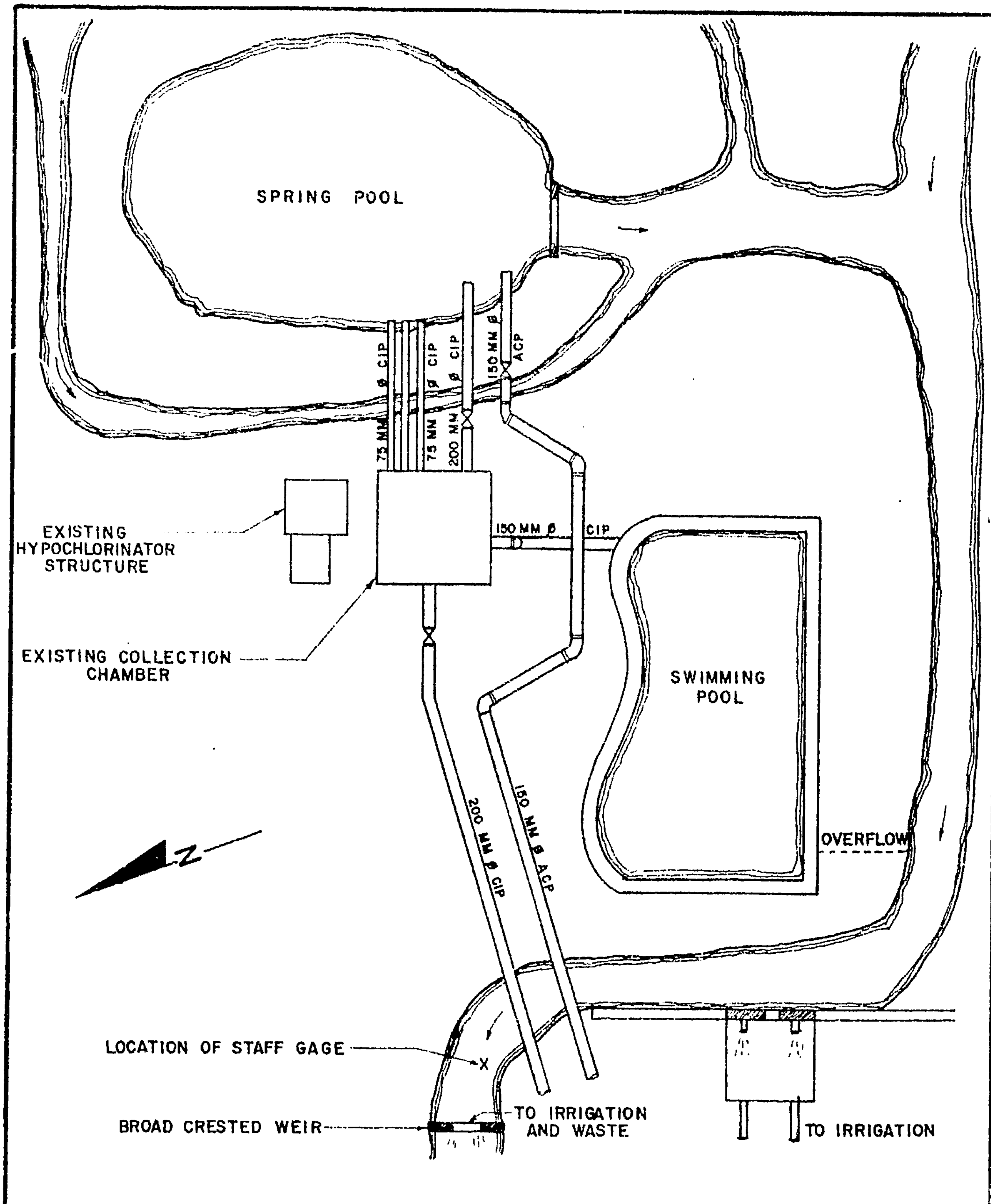


FIGURE IV-2
EXISTING SOURCE FACILITIES
SCHEMATIC
BANGUED WATER DISTRICT

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

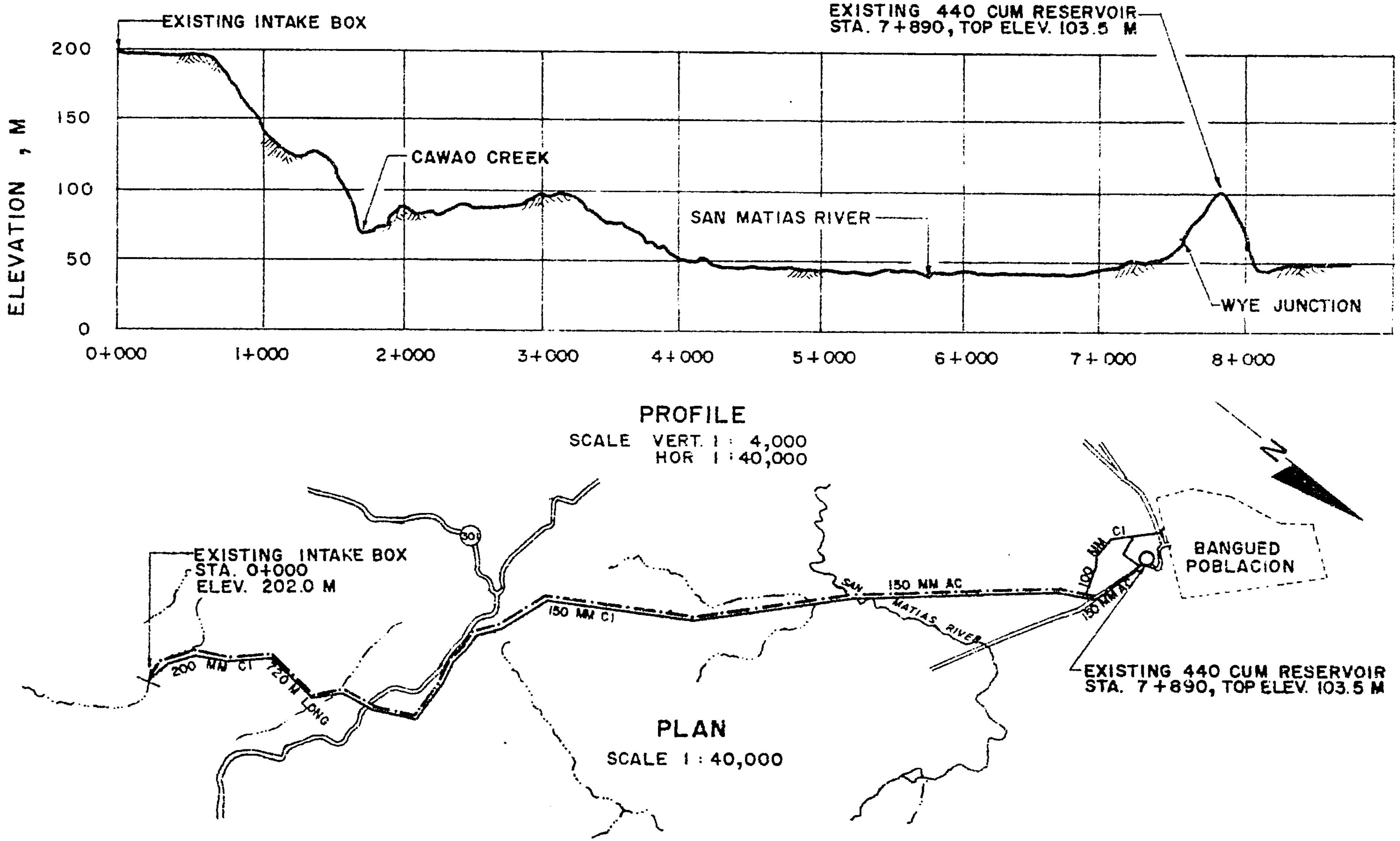


FIGURE IV-3
PLAN AND PROFILE OF EXISTING TRANSMISSION LINES
BANGUED WATER DISTRICT

above mean sea level. As usually operated, water from the spring flows by gravity into the reservoir for about 6 hours each day (12 midnight to 6 a.m.). This water is supplied to the distribution system by opening the outlet valve of the storage tank from 4 a.m. to 6 a.m. Part of the spring water bypasses the storage tank through a 100 mm CI pipe and flows continuously into the distribution system. The reservoir leaks badly when its water level reaches 1.8 meters. The exact location of these leaks has not been ascertained. Water leaking from the reservoir and falling into the valve chamber was measured to be 69 cumd (water level receded inside the tank when the outlet valve was closed) on 7 October 1976. Silt (0.02 m deep) is evident inside the reservoir. Two 50 mm subdrain pipes continuously discharge water into the valve chamber when the water level inside the storage tank is at a height of 1.8 meters. The outside wall of the tank also leaks. A schematic plan of the storage tank is shown in Figure IV-4.

Distribution System

The existing distribution system covers part of Barrio Lipcan and the poblacion in Bangued and Barrio Dumayco and the poblacion in Peñarrubia. The system was first constructed in 1919 and was expanded by about 60 percent, mainly in 1951, with the addition of 50 and 100 mm pipes. About 70 percent of the pipes are made of galvanized iron (GI); the remaining 30 percent, of cast iron (CI); Figure IV-5 shows the existing distribution system.

Pipe Size and Length. The distribution piping has a total length of 11.7 km, including 350 meters of 25 mm pipes directly connected to the second transmission main and extending to Peñarrubia. Ninety-eight (98) percent of the pipes are 100 mm and smaller; the remaining 2 percent are 150 mm in diameter. A description of the pipes by length, size, material and age is given in Table IV-1.

System Pressures. In areas very near the storage tank, water is generally available 24 hours; but pressures are low. Many parts of the Bangued service area have very low or no pressure at all during the daytime, especially at the extremities of the distribution network. Pressures are usually high in Peñarrubia and in areas where pipe connections are made directly to the transmission mains.

TABLE IV-1

SUMMARY OF EXISTING DISTRIBUTION PIPING

Pipe Diameter (mm)	Material	Length of Pipe (m) 1919	1951-Present	Total
25	GI	350	1,260	1,610
50	GI	-	1,565	1,565
75	GI	5,160	-	5,160
100	CI	640	2,480	3,120
150	CI	240	-	240
		6,390	5,305	11,695

Valves and Hydrants. The BAN-WD system has 13 valves and 31 fire hydrants. Most valves are laid under paved roads to a depth of 2 meters. Some of the valves have been lost and non-operational. The fire hydrants are locally made and have 75 mm GI risers. Only about 20 percent of the hydrants are operating. The remaining 80 percent leak and do not have sufficient water for fire-fighting purposes.

Public Faucet The only public faucet, of 12 mm size, is located at the municipal plaza of Bangued and is primarily used for watering plants, washing fire trucks, and general cleaning work.

Service Connections. As of 20 October 1976, there were 868 registered service connections in the water district, all unmetered. Many illegal connections are suspected to exist but the lack of authority makes investigation of these connections difficult. The registered connections 1/ are classified by consumer category into 825 domestic, 32 commercial, and 11 institutional.

Operation and Maintenance

The BAN-WD operates and maintains the water source, storage tank, and transmission and distribution systems. Present operation

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1/ The breakdown of connections by area is as follows: 758 in the Bangued Poblacion, 69 in Barrio Lipcan, 23 in Barrio Dumayco, and 18 in Peñarrubia Poblacion.

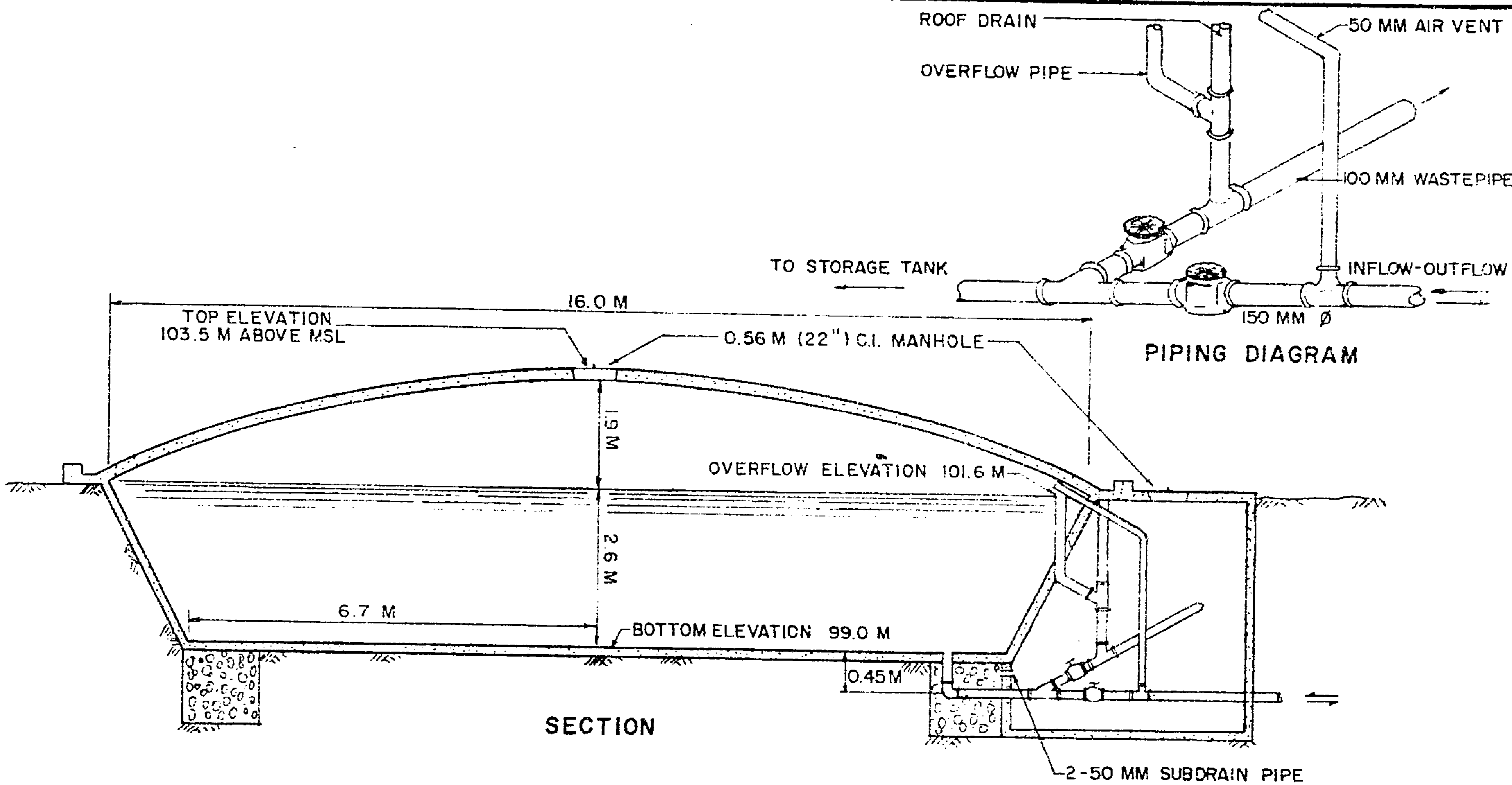


FIGURE IV-4
440 CUM GROUND STORAGE TANK
SCHEMATIC
BANGUED WATER DISTRICT

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

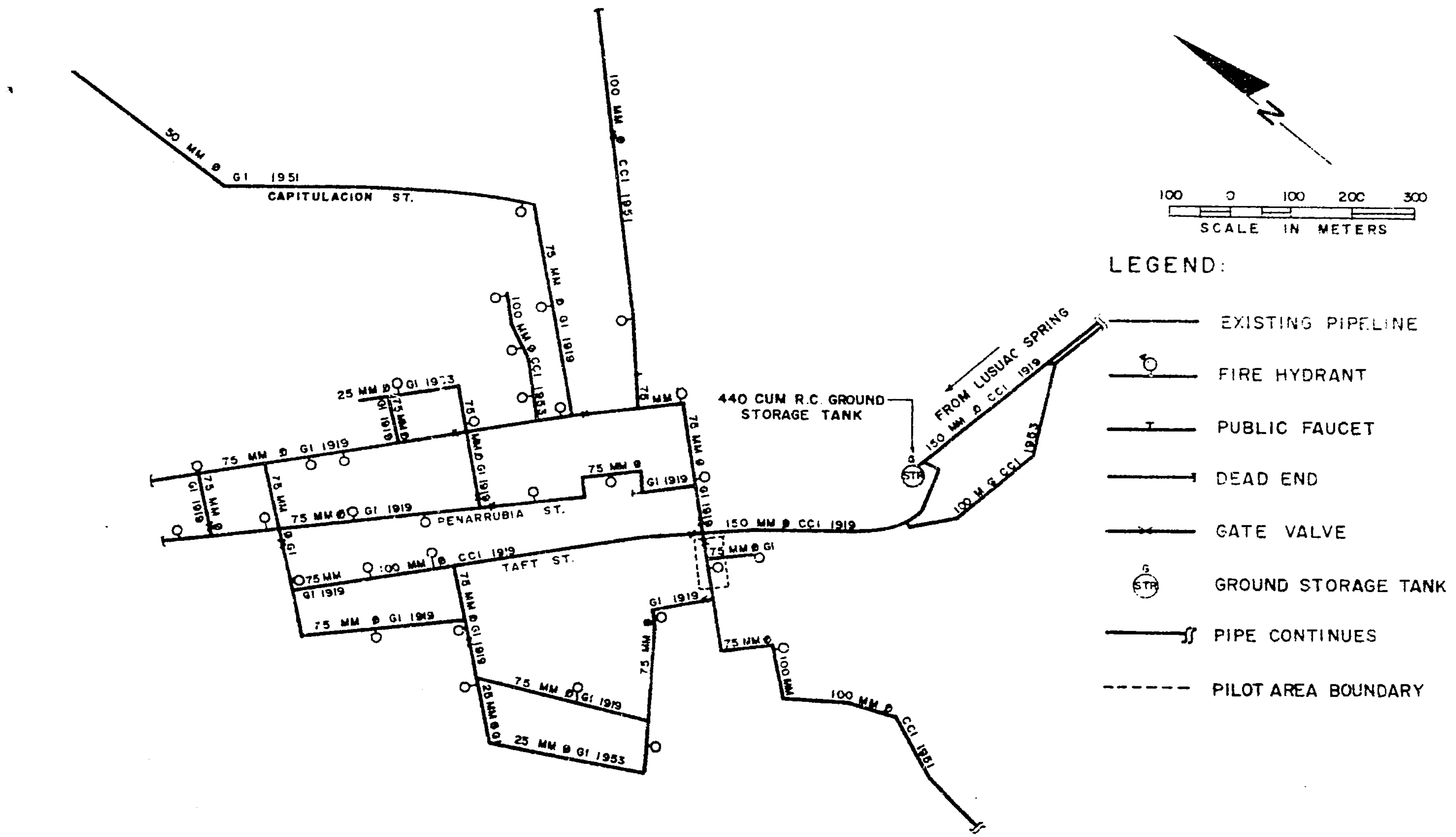


FIGURE IV - 5
EXISTING WATER DISTRIBUTION SYSTEM
BANGUED WATER DISTRICT

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

and maintenance staff includes: 1 section head, 1 valve operator, 1 lineman, 3 plumbers, 1 laborer, and 1 guard at the spring. The work consists primarily of manipulating valves at the reservoir for filling and rationing, repairing leaking mains and service pipes, disconnecting and reconnecting service connections, and maintaining the source.

C. WATER QUALITY

Water samples were taken from Lusuac Spring on 15 September 1976 and 5 March 1977. The results of the analysis of the water samples are compared with the Philippine National Standards for Drinking Water in Table IV-2. Except for the excessive calcium in the second sample of the springwater, other chemical elements are within the permissible limits.

D. WATER USE PROFILE

The water consumption in the BAN-WD has been analyzed to determine its present water accountability. Data used have been obtained from interviews and field measurements in the absence of water meters and records on water production and consumption. Unit water consumption has been quantified through a pilot area survey (see Methodology Memoranda No. 1 and 2).

The estimated consumption figures obtained from the survey have been used to develop the water use profile of the BAN-WD. These figures, however, are still subject to further verification.

Pilot Area Survey

The pilot area, about 1.1 hectares, is located in the southern portion of the present service area. It consists of 26 households with a total population of 208, or an average of 8 persons per household. Interviews show the following: 14 households are registered concessionaires; 3 households are "borrowers" from registered concessionaires; and 9 households obtain their water supply from private wells. These data have been used to derive the number of consumers of the BAN-WD water supply.

Population Served

Water users can be classified as primary users (registered concessionaires) and secondary users (borrowers). The total of 868 registered service connections in the present service area would represent the number of households who are primary users. There are about 185 households in the BAN-WD system that would be borrowers, based on the ratios of the pilot area survey results. Applying the

TABLE IV-2

WATER QUALITY TEST RESULTS
BANGUED WATER DISTRICT

Test	Unit	Permissible Limits	Lusuac Spring 15 Sept 76	Lusuac Spring 5 Mar 77
Physical				
Color	APHA	15	0	0
Turbidity	FTU	5	2	2
Total Dissolved Solids 2/	mg/1	500	299	318
Conductivity	Micromhos/cm	-	460	490
Chemical				
pH		7-8.5	8.3	7.3
Total Alkalinity	mg/1 $CaCO_3$	-	280	270
Phenolphthalein Alkalinity	mg/1 $CaCO_3$	-	20	0
Total Hardness	mg/1 $CaCO_3$	400*	260	270
Calcium	mg/1	75	29.2	100**
Magnesium	mg/1	50	44.8	5
Total Iron	mg/1	0.3	0	0.02
Fluoride	mg/1	1.5	0	0.5
Chloride	mg/1	200	2	5
Sulfate	mg/1	200	0	0
Nitrate	mg/1	-	8	11.1
Manganese	mg/1	0.1	0	0

2/ Computed as 65 percent of conductivity.

*Limit inferred from limits of individual metals causing hardness.

**Exceeds the permissible limits set by the Philippine National Standards for Drinking Water.

pilot area average of 8 persons per household to the water district, total users of the BAN-WD water supply are estimated to be 8,424, of which 6,944 are primary users and 1,480 are secondary users. The average number of persons per household is less than eight in most barrios so that the actual served population (primary users) is only about 6,720 (see Chapter VI).

Unit Consumption

The unit water consumption has been determined on the basis of the pilot area survey results. The estimated daily consumption of each household and the number of persons per household, as given in the survey, have been used to estimate the unit consumption.

The unit consumption is estimated to be 61 lpcd for primary users; 40 lpcd for secondary users; and 95 lpcd for private well owners. The available data are not sufficient to estimate separately the different categories of consumption - domestic, commercial, institutional and industrial.

Accounted-for-Water

The accounted-for-water is defined as revenue-producing water for the water district. Accounted-for-water, however, in the BAN-WD is assumed to be the volume of water consumed by primary users and not necessarily revenue-producing water. The revenue-producing water cannot be determined because the BAN-WD has neither water meters nor an established standard amount of water presumed paid for with flat rates.

The total daily production of 2,600 cumd has been obtained from the measured flow to the storage tank in October 1976. Using the unit consumption of 61 lpcd, the total consumption among the primary users is 423 cumd. Accounted-for-water, therefore, represents only 16.3 percent of total water production. This percentage is lower than the average accounted-for-water of 21 percent of total production obtained for the First Ten Provincial Urban Areas.

Unaccounted-for-Water

Unaccounted-for-water includes leakage, wastage, borrower's usage, use greater than inferred flat-rate usage (underestimated flat-rate use), illegal connections, and other uses. The total unaccounted-for-water in the BAN-WD is 2,177 cumd or 83.7 percent of water production. It is difficult to estimate the volume of water in each category of unaccounted-for-water because of insufficient data.

Although actually consumed, borrowers usage has been considered part of unaccounted-for-water because it is not revenue-producing since borrowers are not duly registered concessionaires. Borrowers' usage is about 65 cumd or 2.5 percent of total water production. Wastage, leakage and other uses comprise 81.2 percent of total production, including leakage in the reservoir of 2.5 percent.

Summary of Water Accountability

The water accountability in the BAN-WD is summarized in Table IV-3. The accounted-for-water is based on the total consumption of primary users. It is estimated to be 423 cumd or 16.3 percent of total water production. The unaccounted-for-water includes wastage at flat-rate connections, leakage, borrowers' usage, overestimated flat-rate use and other uses. The unaccounted-for-water represents 2,177 cumd or 83.7 percent of total production.

TABLE IV-3

SUMMARY OF WATER ACCOUNTABILITY

Category	Amount of Water (cumd)		Percent of Production (%)	
1. Accounted-for-water				
a) Flat-rate use	423		16.3	
Sub-total		423		16.3
2. Unaccounted-for-water				
a) Usage of borrowers from concessionaires	65		2.5	
b) Wastage, leakage and other uses	2,112		81.2	
Sub-total		2,177		83.7
3. Total Production		2,600		100.0

E. HYDRAULIC STUDIES

A hydraulic survey of BAN-WD was conducted from April 26 to May 6, 1977 to obtain data for a computer model of the existing system and to identify parts of the system having operational problems. The survey showed the following data:

Pipe Carrying Capacities. Hydraulic tests were made on the transmission pipelines from the Lusuac Spring to Peñarrubia and to the wye-junction on the two parallel pipelines (see Figure IV-6). Tests were conducted to determine the carrying capacities, measured as the Hazen-Williams "C" value, of the transmission lines that were constructed more than half a century ago. The old GI pipeline laid in 1919 has a "C" value varying from 124 to 128 while the new line, asbestos-cement (AC) pipeline laid in 1953 has a "C" value of 34 to 110. The low "C" value of 34 from the source to Peñarrubia is attributed to extensive leakage in the transmission line. Normally, an AC pipeline retains a high "C" value for many years. Table IV-4 shows the tabulated "C" value of both pipelines including lengths and elevations.

System Pressures. Two continuously recording pressure gages were alternately installed on five fire hydrants located in the distribution system as shown on Figure IV-6 to measure the distribution system pressures for 24 hours. Comparative pressures on Annex Table IV-E-1 and Annex Figures IV-E-5 coincided with the times the reservoir was filling, was emptying or was empty. Pressures obtained from hydrant no. 1 varied from 1.06 to 4.95 m while hydrant no. 2 varied from 0.70 to 3.55 meters. Pressures at hydrants no. 3 and 5 located in the western portion of the distribution system were 0.70 to 3.95 meters and 0.80 to 4.95 meters, respectively. Pressures at hydrant no. 4 varied from 1.30 to 3.75 meters.

Single pressure readings were taken along the transmission lines from the source to the wye-junction. Pressures on the GI pipeline were 0.5 meters at the source, 60 meters at Peñarrubia and 61 meters at the wye-junction. Pressures on the AC pipeline were 0.1 meters at the source, 33 meters at Peñarrubia, and 61 meters at the wye-junction. Pressures at the by-pass line to the storage tank was 59 meters.

System Flows

Flow gaging utilizing a pitot tube was conducted on the two parallel transmission lines to determine the amount of water flowing into the pipelines, water losses in transmission mains and pipe hydraulic conditions. A schematic plan of the gaging stations is shown in Figure IV-6. with flow conditions tabulated in Table IV-4. Figure IV-7 shows the hydraulic gradeline of the transmission pipelines.

Flow measurements made along the 150-mm AC transmission line indicate that the water lost from Lusuac Spring to Peñarrubia is about 1,040 cumd which is 55 percent of the water entering the line at the spring. From Peñarrubia to the wye junction, 260 cumd is lost which is 30 percent of the flow recorded at Peñarrubia.

Between the spring and Peñarrubia, there is a 770 cumd reduction in flow in the GI pipeline. From Peñarrubia to the wye junction, 130 cumd of water is lost which is only 6.5 percent of the water in the line at Peñarrubia. The water lost in these two pipelines includes the flow to Peñarrubia, however, it is not possible to determine the exact amount used in Peñarrubia and how much was leakage.

Water flowing into the 100-mm GI by-pass line was measured to be 200 cumd; thus, the flow into the reservoir was estimated to be 2,260 cumd.

TABLE IV-4

FLOW MEASUREMENTS

A. 150-mm GI Transmission Line

Location	Discharge (cumd)	Velocity (m/sec)	Pressure (m)	Elevation (m)	Length (m)	"C" Value
Lusuac	2,760	.98	.5	200	3,230	124
Peñarrubia	1,990	1.36	60	98	4,130	128
Bacsil 4/	1,860	1.25	61	53		

B. 150-mm AC Transmission Line

Location	Discharge (cumd)	Velocity (m/sec)	Pressure (m)	Elevation (m)	Length (m)	"C" Value
Lusuac	1,900	1.22	.1	200		
Peñarrubia	860	.54	33	88	3,250	34 3/
Bacsil 4/	600	.4	61	53	4,110	110
By-Pass 5/	200	0.29	59	53	-	-

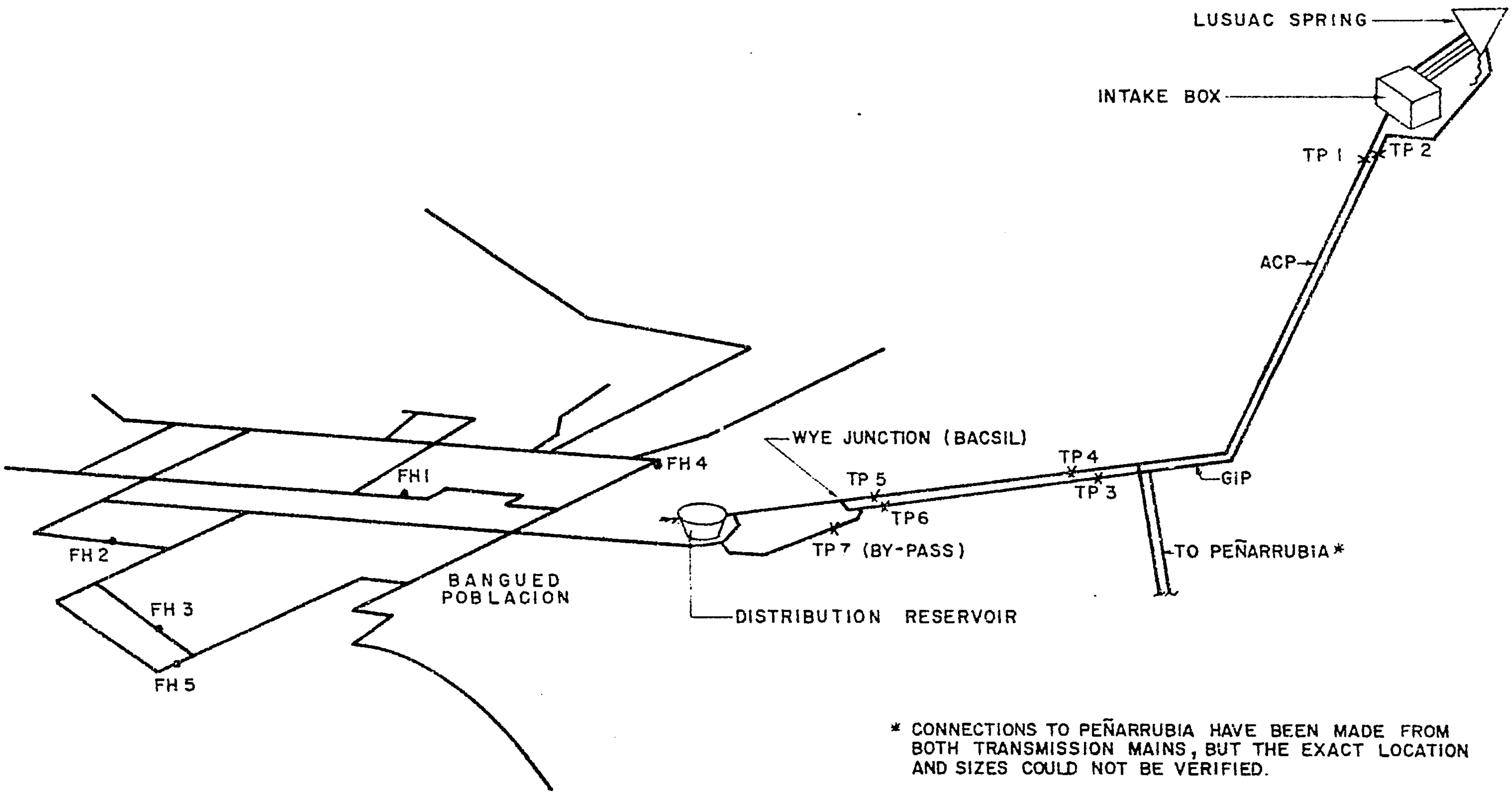
F. COMPUTER STUDIES

The purpose of conducting computer studies on the existing transmission and 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.

3/ Abnormally low "C" value for this type of pipe due to excessive leakage in this section.

4/ Location of the wye-junction

5/ 100-mm CI by-pass to the storage tank.



* CONNECTIONS TO PEÑARRUBIA HAVE BEEN MADE FROM BOTH TRANSMISSION MAINS, BUT THE EXACT LOCATION AND SIZES COULD NOT BE VERIFIED.

FIGURE IV-6
FLOW MEASUREMENT LOCATION
BANGUED WATER DISTRICT

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

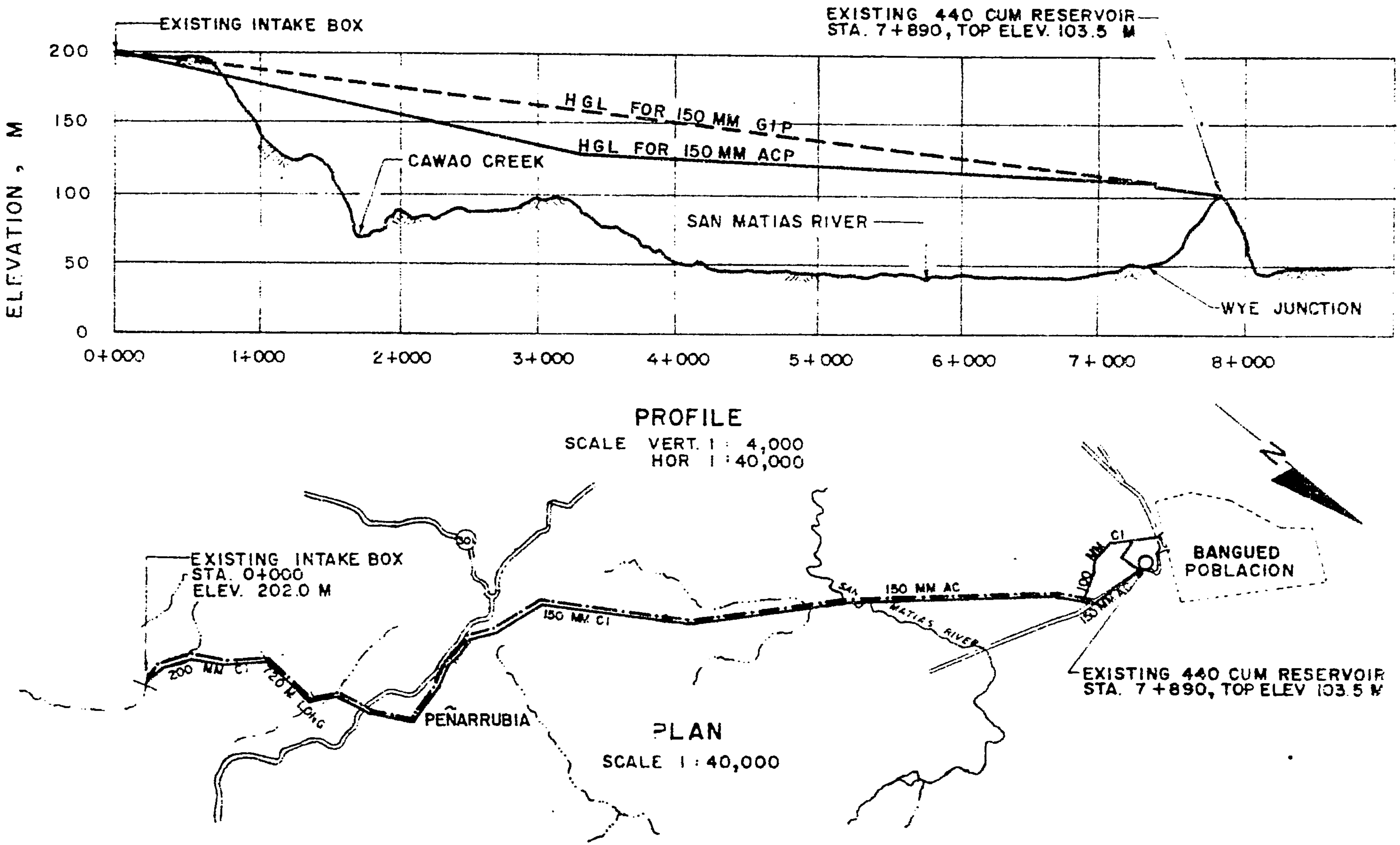


FIGURE IV-7
EXISTING HYDRAULIC GRADELINE
BANGUED WATER DISTRICT

In order to provide field data for computer studies, there must be a significant positive pressure over the entire distribution system during field tests. There were very little field data gathered in Bangued for the existing system that could be used for computer modeling, therefore, computer studies on the existing system were not conducted.

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

G. DEFICIENCIES OF THE EXISTING SYSTEM

Only 16.3 percent of the water produced by the BAN-WD is accounted for; more than 80 percent of the water is lost through leakage and wastage. Despite an adequate production of 2,600 cumd for the present number of service connections, a water shortage prevails in Bangued. Most consumers at the western fringes of the service area have water service for only 3-4 hours daily. Leakage and wastage are major reasons for the water shortage. Moreover, service is intermittent and pressures are usually low in Bangued. Some concessionaires have requested disconnection from the water system.

Leakage is evident in the transmission mains, the storage tank and the distribution system. Leak repair is usually makeshift, with the use of rubber strips, apparently because funds for proper maintenance are lacking.

The water supply is subject to potential sources of contamination. Contamination of water at the intake box is possible because its overflow pipe is valveless; this may allow backflow of water from the swimming pool to the intake box. The spring impoundment is not covered, exposing it to airborne contamination. The spring site is often visited by excursionists, adding to the hazard of possible contamination. The water supply is not disinfected. The water district has no routine sampling and testing program.

Part of the water in the transmission line is believed to be illegally diverted for irrigation. Most of the pipelines are 58 years old and have reduced carrying capacity. Automatic air release valves on the transmission lines are missing. Much of the leakage appears to be at the joints of the transmission mains.

The reservoir is seldom cleaned - once every 3 years. Silt deposited inside the reservoir measures 0.02 meter deep. The reservoir leaks badly; the leaks, however, have not been located.

When the stored water is supplied to the distribution system from 4 a.m. to 6 a.m., the storage tank is left empty without any provision for fire protection.

Many illegal connections are suspected to exist in the system. (For instance, an illegal 25 mm line has been discovered parallel to a 75 mm pipe installed along Peñarrubia Street). At present, the existing distribution system consists of a complex network of small pipes laid by private plumbers. About 70 percent of distribution piping is 75 mm and smaller in diameter.

Most fire hydrants are leaking and inoperative and cannot provide sufficient water for fire-fighting. Locations of most valves are unknown; several of them are also inoperative.

There are numerous potential cross-connections between water pipes and polluted water. Many pipes are laid in drains under polluted water. The pipes are subject daily to low (sometimes negative) pressures, increasing the danger of contamination.

The BAN-WD lacks the basic tools, equipment and material stocks for proper repair and maintenance of the system. Parts needed for pipeline improvement are taken from existing parts of the system. There are no transportation, meters, plumbing shop or administration facilities. Plans of the existing system are incomplete and inaccurate.

ANNEX IV-E

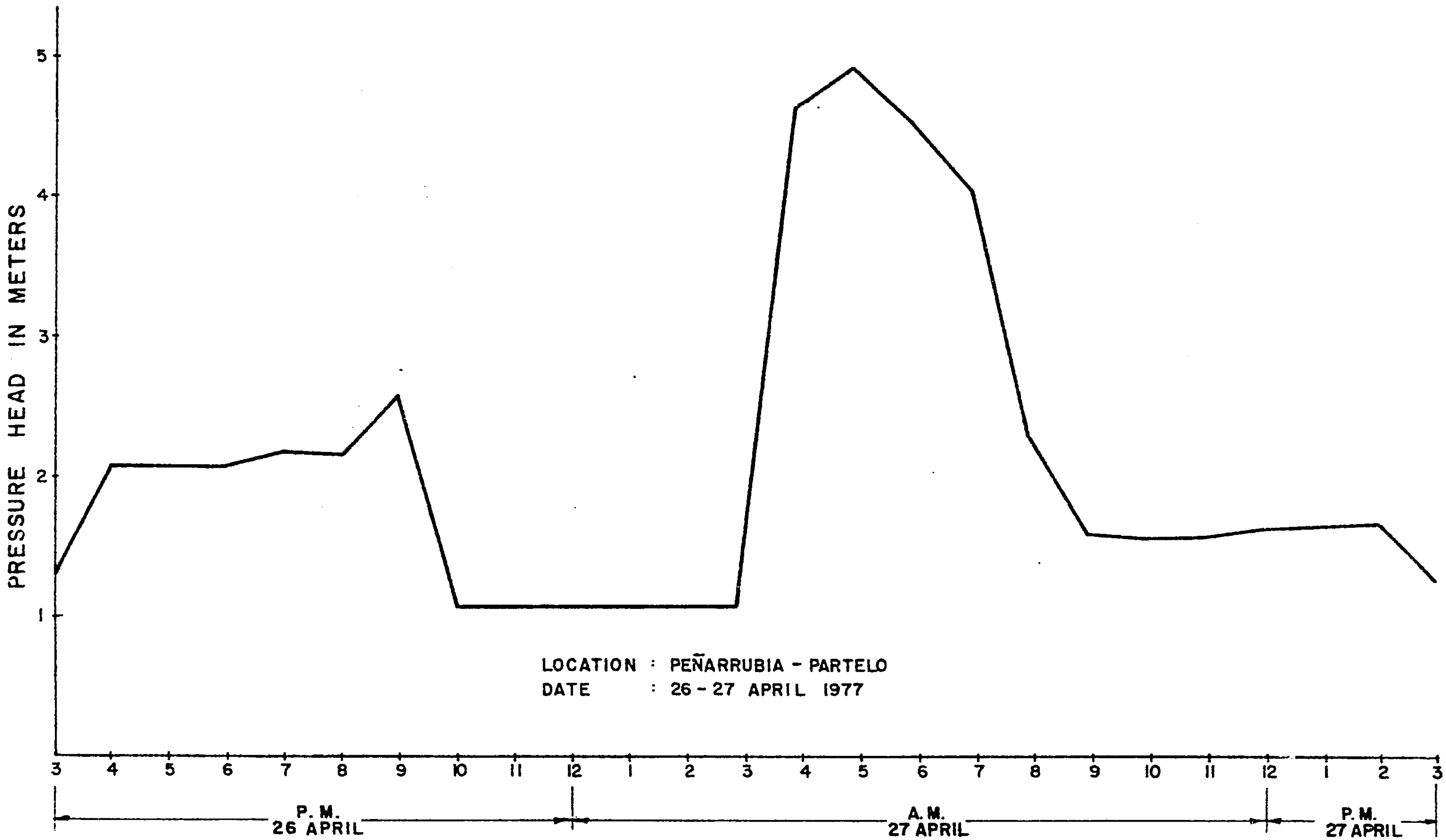
HYDRAULIC STUDIES

ANNEX TABLE IV-E-1

VARIATION IN DISTRIBUTION SYSTEM PRESSURE (m)
(Dominant Pressure)[1/]

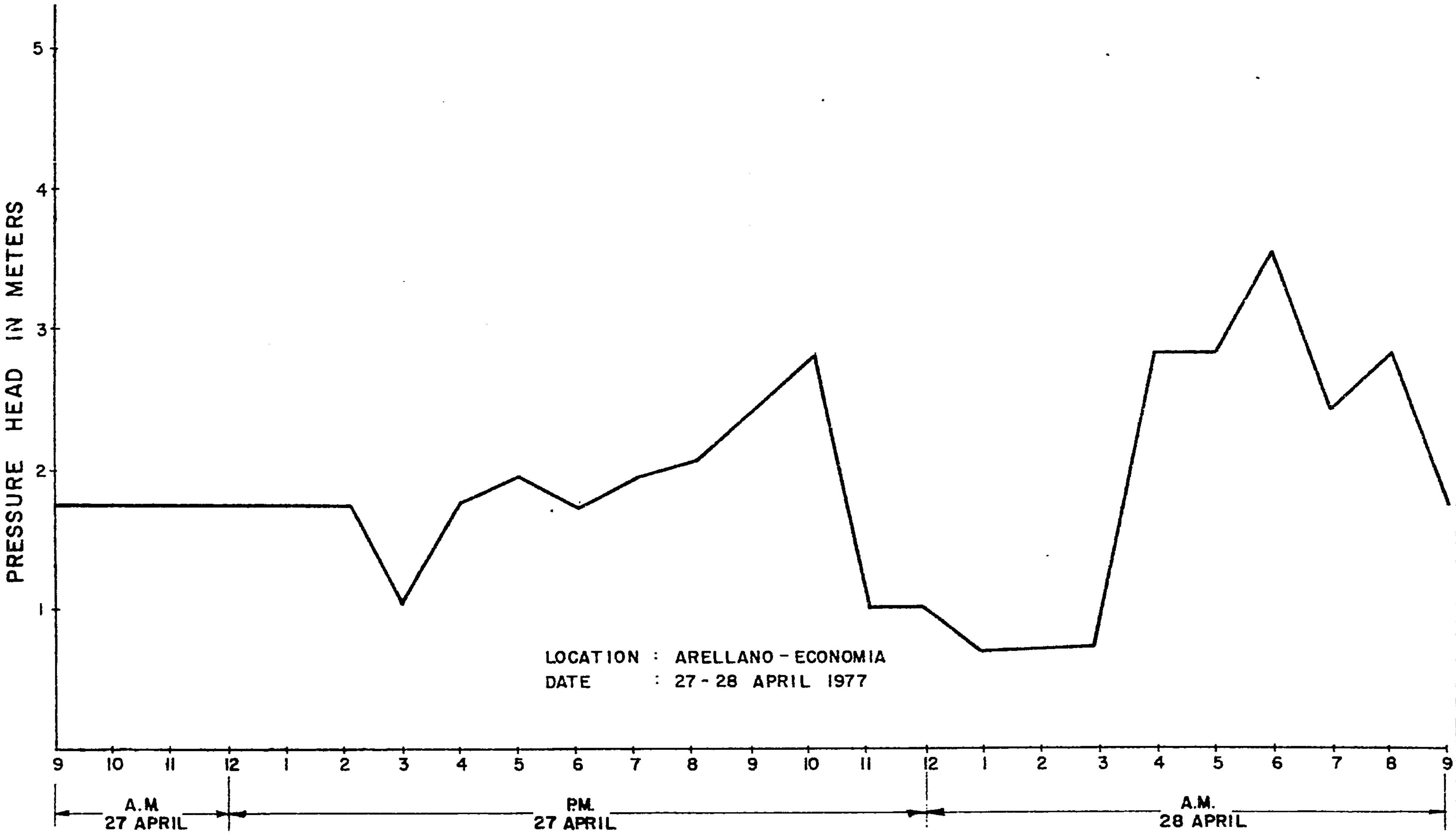
	Location	Date April 1977	Reservoir Filling (10:00PM-4:00AM)	Reservoir Emptying (4:00AM-8:30AM)	Reservoir Empty (8:30AM-10:00PM)
1.	Peñarrubia corner Partelo St.	26-27	1.06 - 4.70 (1.06)	1.80 - 4.95 (3.30)	1.06 - 2.60 (2.11)
2.	Arellano corner Economia St.	27-28	0.70 - 2.82 (0.70)	2.05 - 3.55 (2.85)	1.03 - 2.82 (1.76)
3.	M.H. del Pilar corner Benedito St.	27-28	0.75 - 2.85 (0.75)	2.10 - 3.95 (3.00)	(1.65 - 2.85) (1.80)
4.	Santiago corner Magallanes St.	28-29	1.30 - 2.70 (1.30)	1.30 - 3.75 (3.02)	1.75 - 2.70 (2.46)
5.	Borbon corner Rizal St.	29-30	0.80 - 2.90 (0.80)	0.80 - 4.95 (3.52)	1.25 - 2.90 (1.50)

[1/] Dominant pressures during the period indicated.

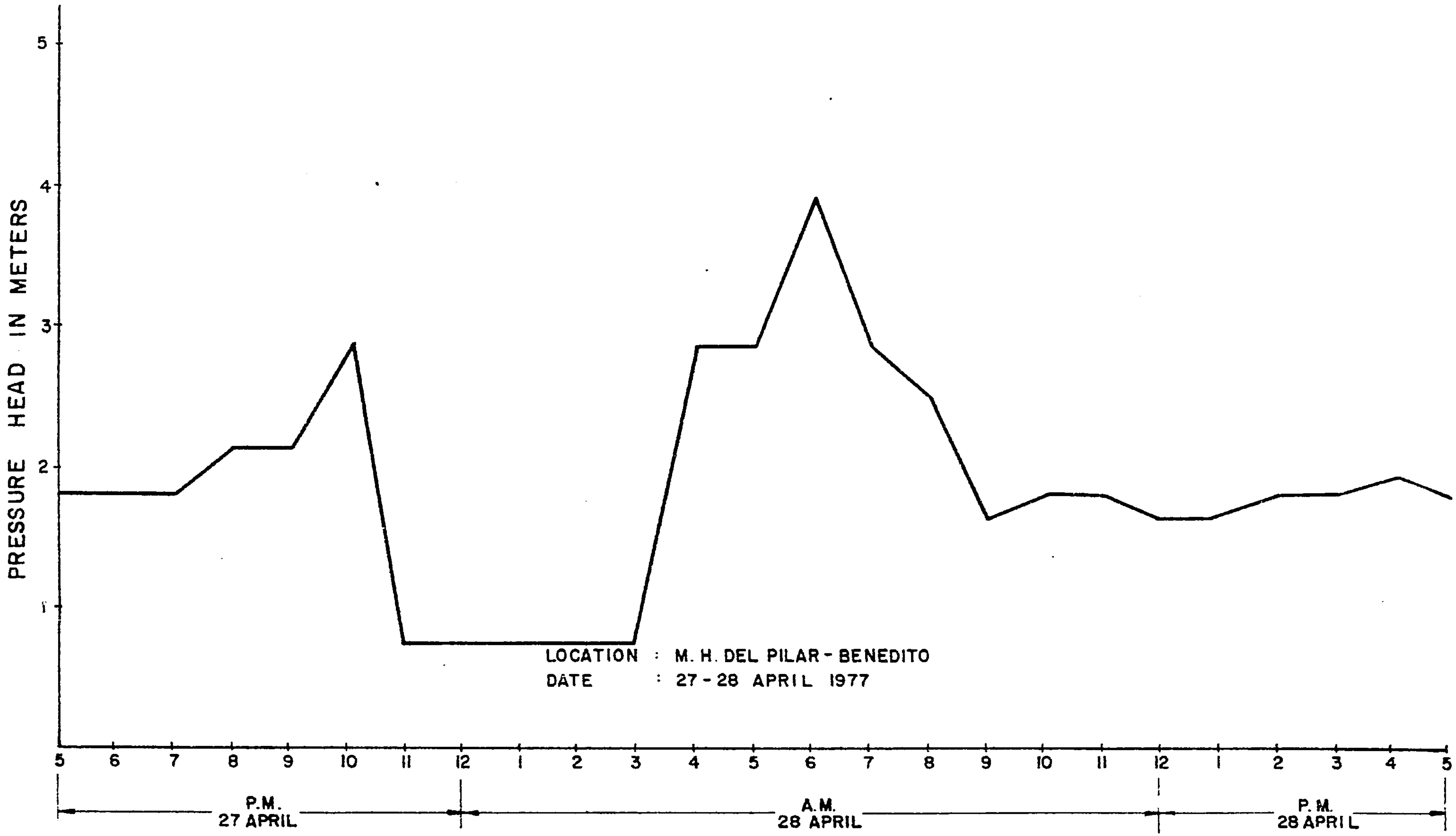


ANNEX FIGURE IV-E-1
24-HOUR SYSTEM PRESSURE AT FIRE HYDRANT NO. 1
BANGUED WATER DISTRICT

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

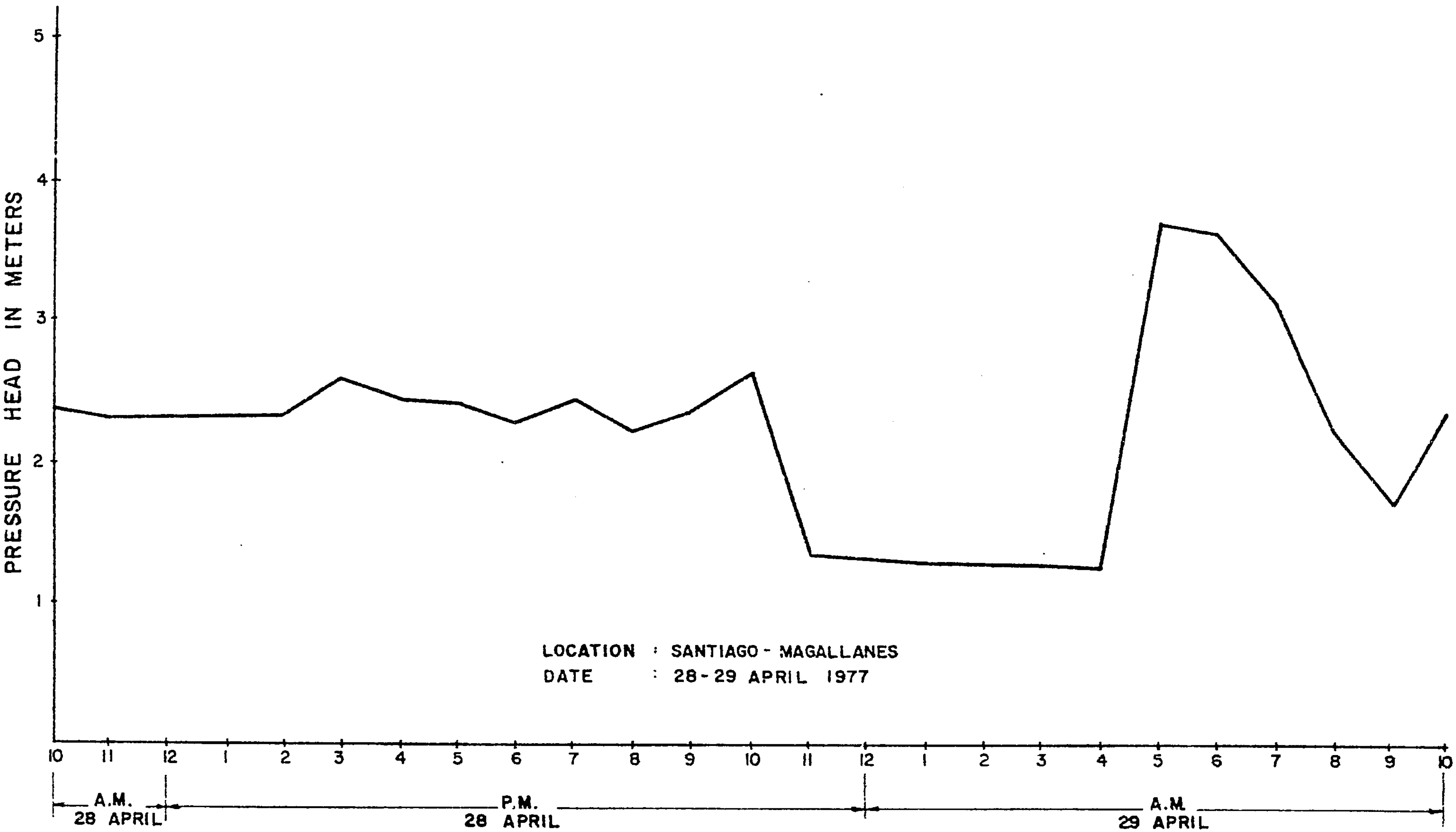


ANNEX FIGURE IV-E-2
24-HOUR SYSTEM PRESSURE AT FIRE HYDRANT NO. 2
BANGUED WATER DISTRICT

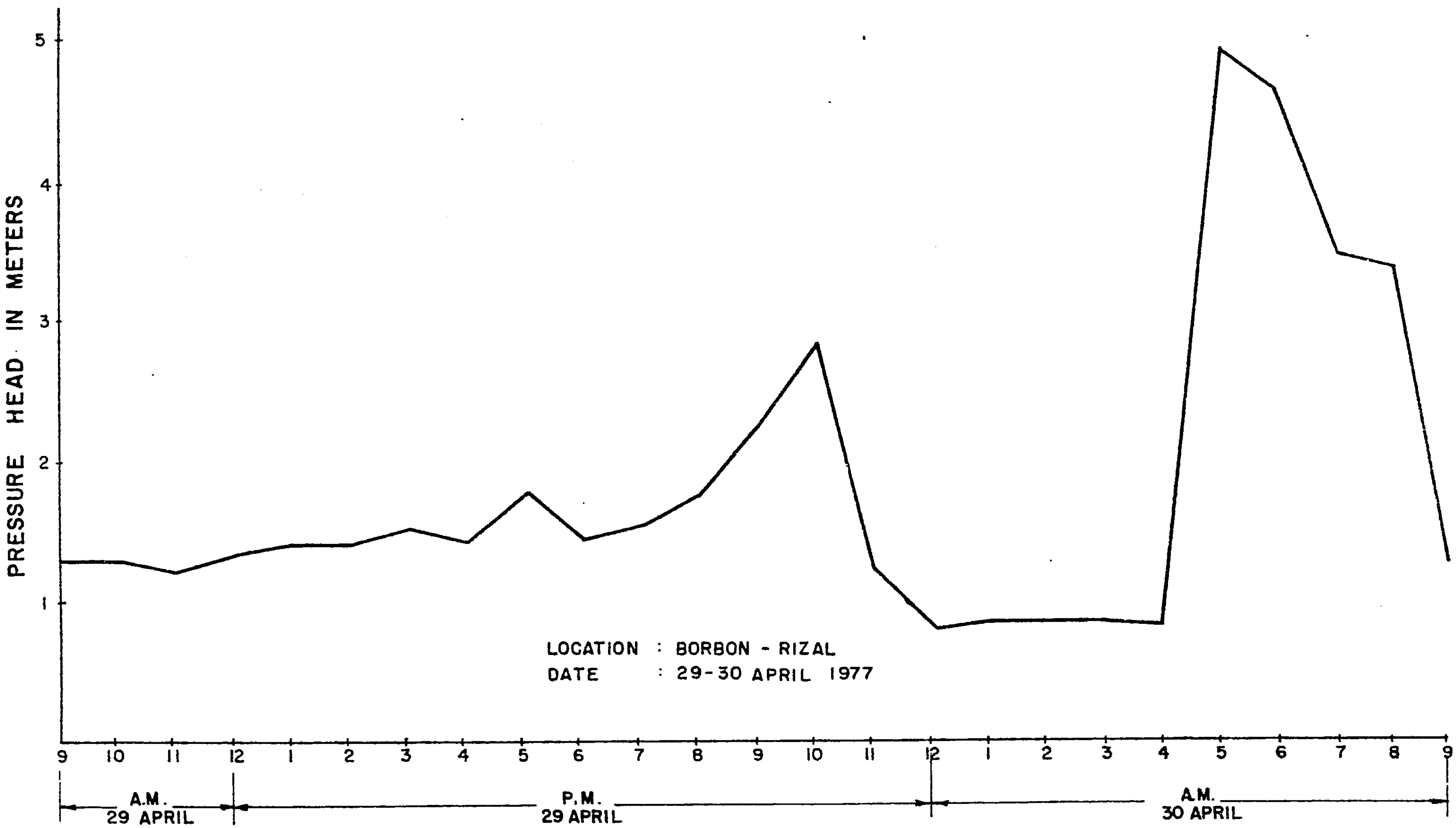


ANNEX FIGURE IV-E-3
24-HOUR SYSTEM PRESSURE AT FIRE HYDRANT NO. 3
BANGUED WATER DISTRICT

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



ANNEX FIGURE IV-E-4
24-HOUR SYSTEM PRESSURE AT FIRE HYDRANT NO. 4
BANGUED WATER DISTRICT



ANNEX FIGURE IV-E-5
24-HOUR SYSTEM PRESSURE
AT FIRE HYDRANT NO. 5
BANGUED WATER DISTRICT

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

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), the choice 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. <u>Areawide Approach</u>: 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. <u>Source of Water</u>: Groundwater and surface water have been given equal consideration as potential sources of water. However, based on the first 10 feasibility studies, disinfected groundwater derived from deep wells, when available, is expected generally to be more economical than conventionally treated surface water.

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

4. <u>Conservation</u>: 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. <u>Stage Development</u>: 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	Start Construction 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 on 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.

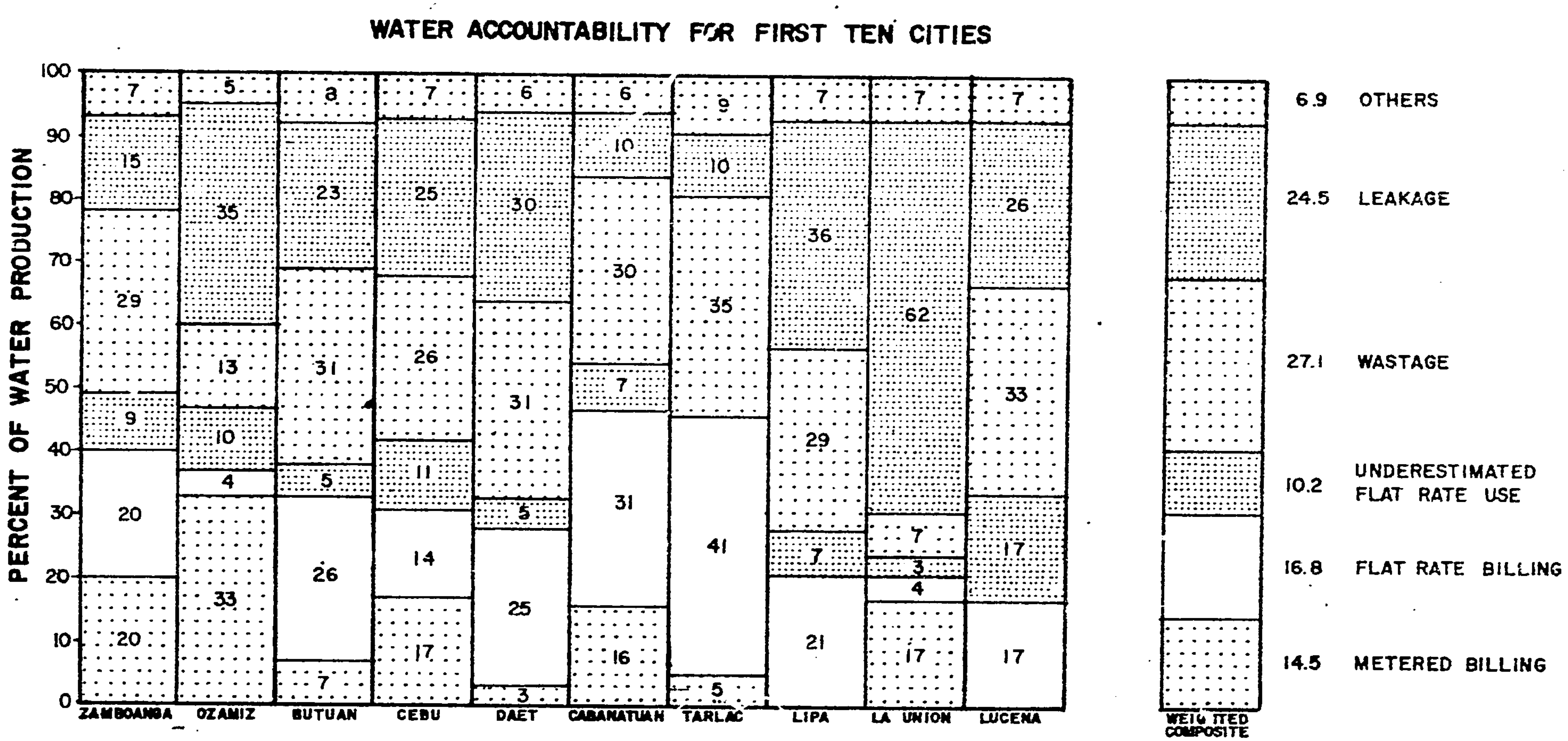
9. Social Soundness: The successful completion of any project must take into account the social acceptability of its recommended programs (Appendix S, Volume II).

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 attached herein in Volume I.

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 in 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).

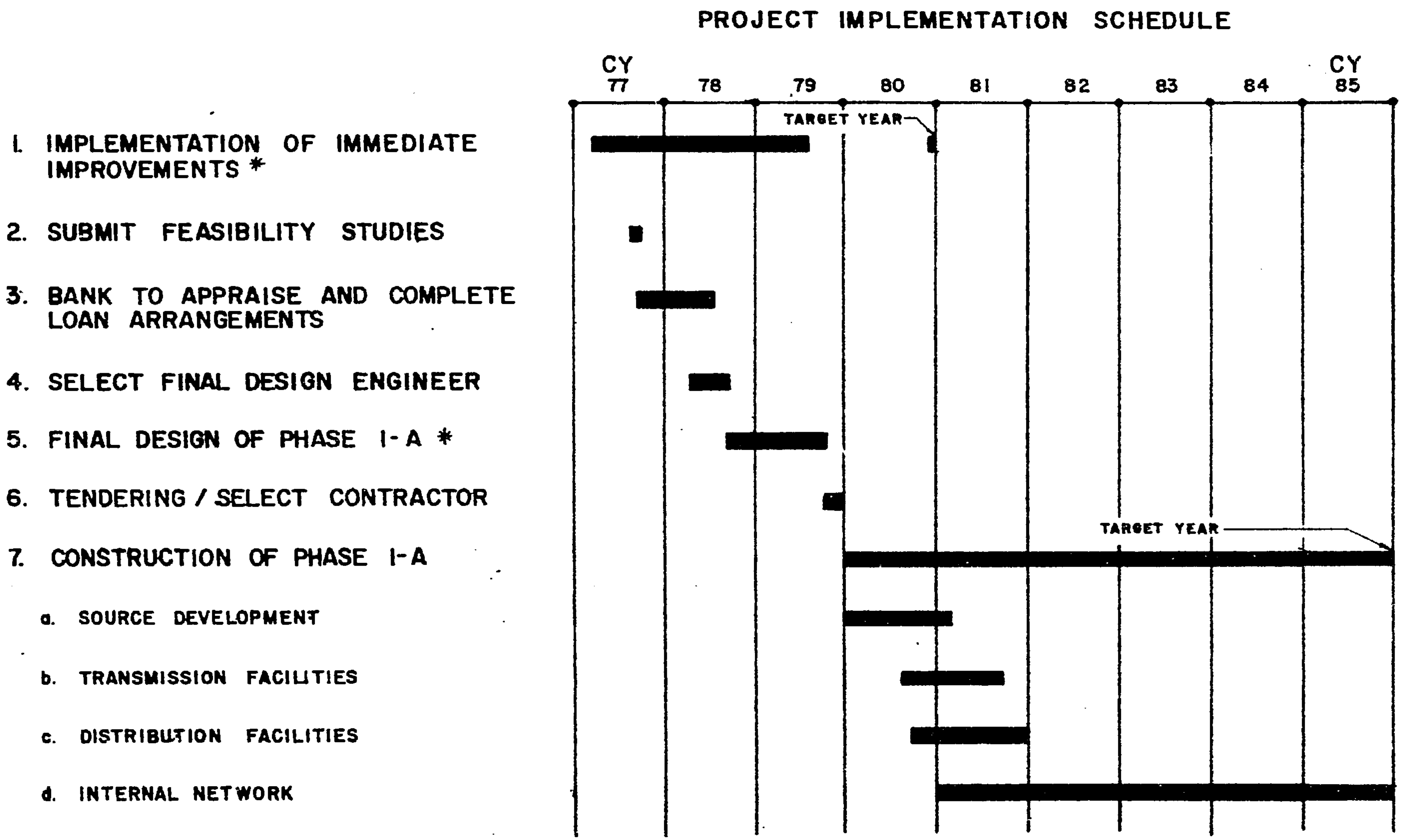
E. BASIS OF COST ESTIMATES

Construction cost curves have been developed for in-place 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.

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	Early 1981
b) Distribution	Early 1982
c) Internal Network	Late 1985



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

FIGURE V-2
PROJECT IMPLEMENTATION SCHEDULE

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 materially affect facility layouts and sizes, construction staging and the cost of the project. These projections are developed for the BAN-WD in this chapter.

B. POPULATION PROJECTIONS

The historical population growth rates in the municipalities of Bangued and Peñarrubia for the period 1948 to 1975 show a declining trend similar to, but more pronounced than, the decline in the national growth rate for the same period. In the 2 municipalities, this decline in the population growth rates (Peñarrubia had a marked decline in population between 1970-1975) is attributed to an absence of industrial and commercial development and problems of peace and order prior to martial law declaration in 1972. These factors prevented real development in both municipalities. The populations and respective growth rates for Bangued, Peñarrubia, Abra Province, and the Philippines are as follows:

	Population		Annual Growth (%)			
Year	Bangued	Peñarrubia	Bangued	Peñarrubia	Abra	Philippines
1948	14,792	2,262	-	-	-	-
1960	19,371	3,117	2.4	2.9	2.5	3.1 (1948-1960)
1970	24,587	3,955	2.4	2.4	2.31	3.0 (1960-1970)
1975	25,597	3,737	0.81	-1.1	0.20	2.66 (1970-1975)

Data gathered in the field indicate that future population growth rates will exceed those in the past. The primary factors expected to stimulate faster growth are: (1) the new industries and commercial establishments; and (2) the improved peace and order situation.

Based on field inspection and discussions with local and water district officials, by the year 2000, the water district is expected to serve the poblaciones of Bangued and Peñarrubia and the principal portions of barrios Dangdangla, Riang, Calaba, Patucannay, Bangbangar, Palao, Agtañgao, Lipcan, Sao-atan and Dumayco. Figure VI-1 indicates the present, immediate and projected 1990 and year 2000 service areas of the BAN-WD.

Population projections have been made for the expected water service areas. Data such as past population trends of the municipality, land use and development plan, physical limits of urban areas, and existing and proposed future facilities, which were gathered by field inspection in the study area, have influenced these projections. More rapid growth is projected for the service area than that in the past or projected by NEDA-POPCOM[1]. The municipalities are primarily rural and it is believed that a much higher growth rate will be experienced by the urban area served by the BAN-WD than by the entire municipality.

Projected populations are listed in Table VI-1 and summarized below:

Year	Total Population[2]	Overall Annual Growth Rate	Population in Service Area	Area (ha)	Average Density in Service Area (persons/ha)
1975 (Present)	18,443	-	10,840	135	80
1980 (Immediate)	21,040	2.67% (1975-1980)	14,350	155	93
1990	29,050	3.28% (1980-1990)	23,700	294	81
2000	37,200	2.50% (1990-2000)	35,440	374	95

The analysis shows that the population in the service area (see Figure VI-2) will increase from 10,840 in 1975 to 35,440 in the year 2000. The growth will mostly occur in the present service area; the growth in the future service area extension will gradually increase from 1980 to 2000. Likewise growth in the present and future service areas is slightly higher from 1990 to 2000 than from 1980 to 1990. Projected densities in the service area will vary between 80 and 95 persons per hectare from 1975 to 2000. The total population of the areas to be served by the BAN-WD will double from 18,443 in 1975 to 37,200 in 2000. Overall annual growth rates in these areas will fluctuate from 2.67 percent in 1975 to 1980 to 3.28 percent in 1980 to 1990 and 2.50 percent in 1990 to 2000.

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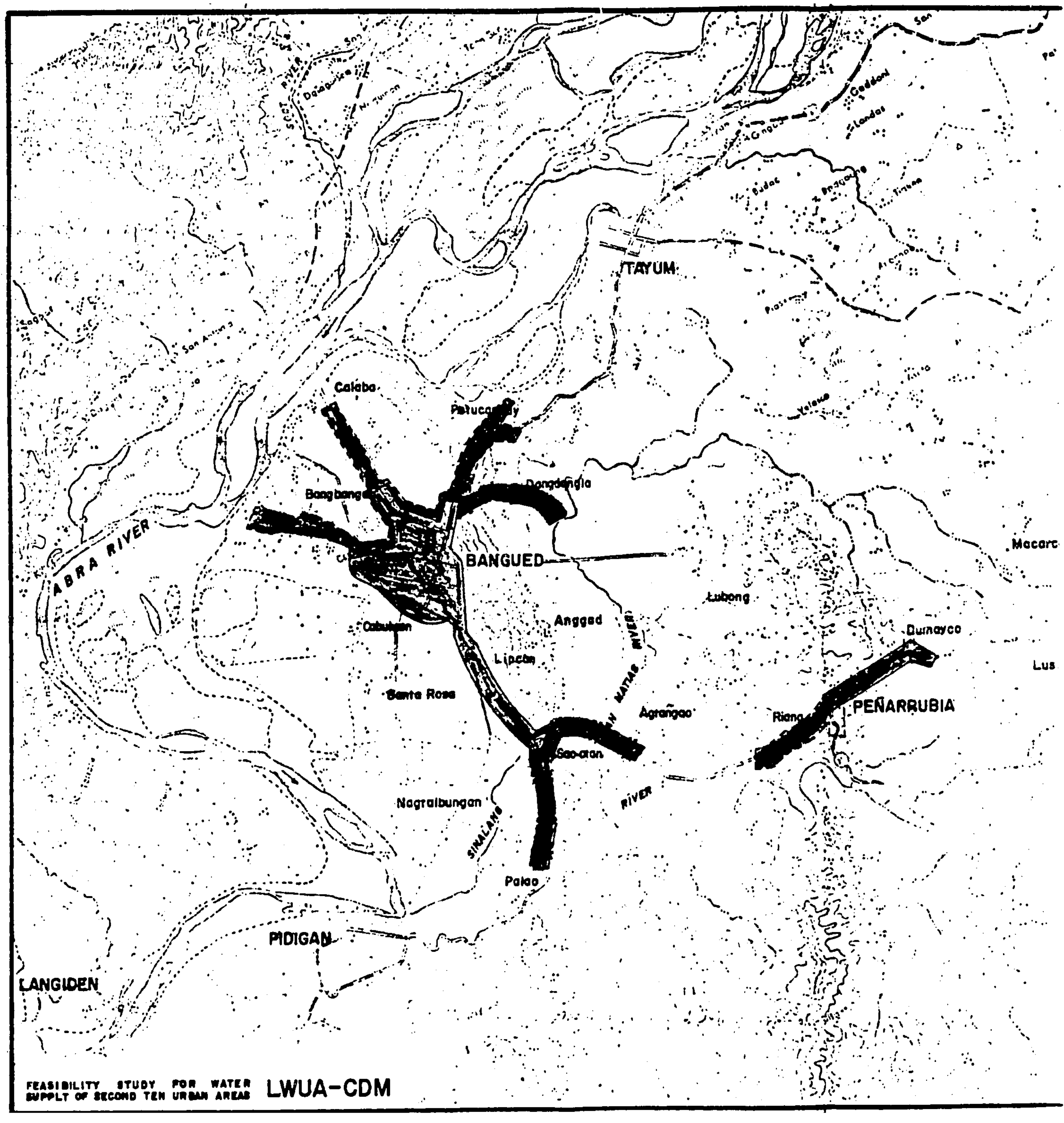
[1] NEDA-POPCOM assumes 1.68-2.67 percent growth rates from 1975 to 1990. However, future growth rates are expected to exceed these assumptions. (Appendix H, Volume II).

[2] Of poblaciones (Bangued and Peñarrubia) and other barrios in the served area.


TAYUM
Calaba
Patucannay
Dangdangla
Bangbangar
BANGUED
ABRA RIVER
Lubong
Anggad
Macarcarmay
Cabuloan
Dumayco
Lipcan
Lus
Santa Rosa
Agtangao
Riang
PEÑARRUBIA
Sao-atan
RIVER
Nagrabungan
SINALANG
Palao
PIDIGAN
LANGIDEN
FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS
LWUA-CDM

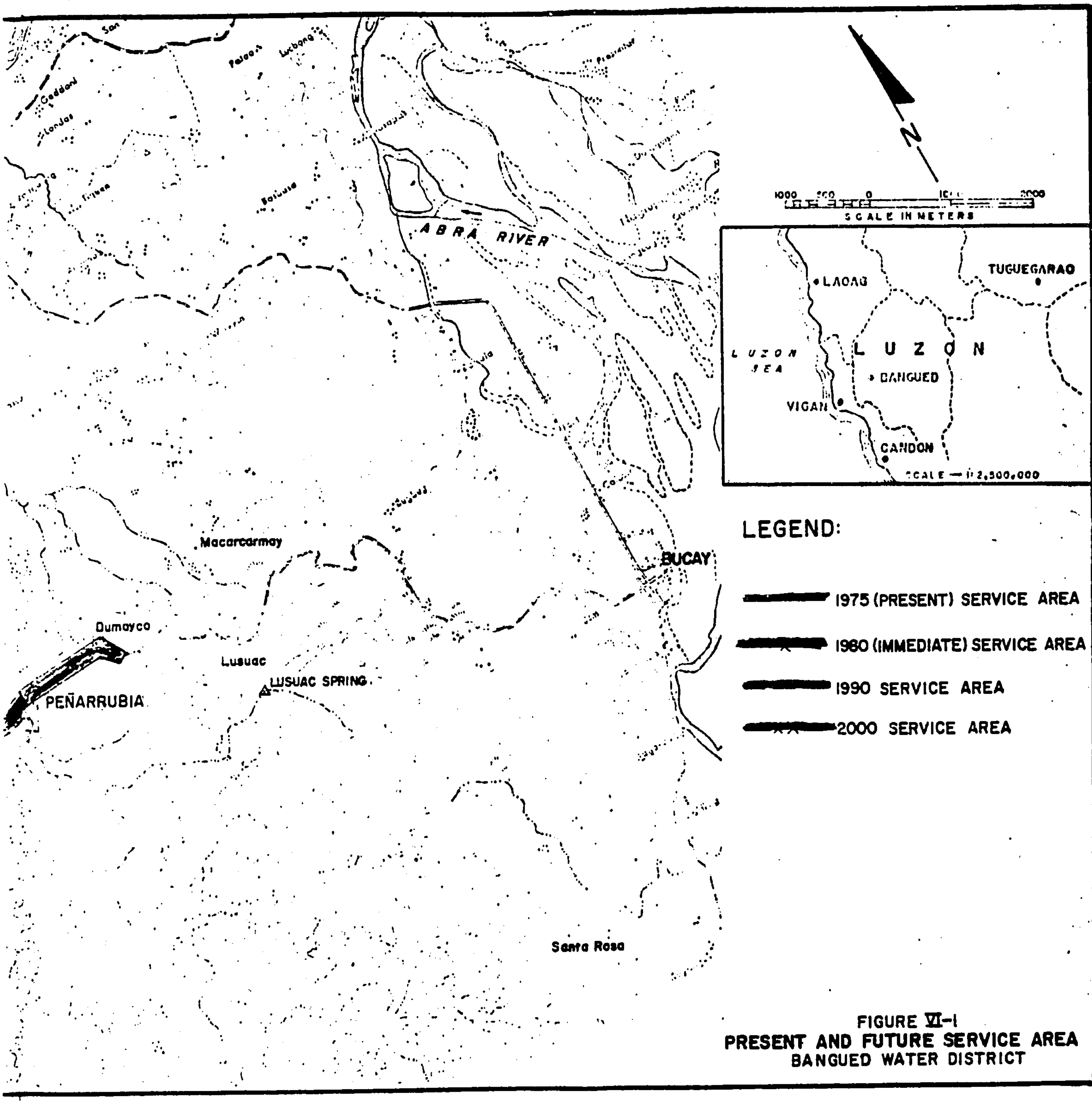


FIGURE VI-1
PRESENT AND FUTURE SERVICE AREA
BANGUED WATER DISTRICT

TABLE VI-1

SERVICE AREA POPULATION PROJECTIONS
BANGUED WATER DISTRICT

		Present Service Area				Immediate Service Area				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)	
Bangued																	
Poblacion	10,135	10,135	82	124		11,968	82	149		16,880	82	206		22,688	82	277	
Lipcan	797	319	25	13		740	25	30		1,120	25	45		1,637	32	51	
Dangdangla	658	-	-	-		378	20	19		520	20	26		835	20	42	
Calaba	1,253	-	-	-		-	-	-		1,490	40	37		2,081	40	52	
Bangbangar	938	-	-	-		-	-	-		585	30	20		1,122	30	37	
Patucannay	854	-	-	-		-	-	-		1,065	45	24		1,703	45	38	
Agtañgao	815	-	-	-		-	-	-		-	-	-		957	30	32	
Sao-atan	409	-	-	-		-	-	-		-	-	-		453	18	25	
Palao	907	-	-	-		-	-	-		-	-	-		1,064	25	43	
Peñarrubia																	
Poblacion	659	264	18	15		694	18	39		1,035	18	58		1,325	18	74	
Dumayoo	615	122	10	12		570	10	57		755	24	31		1,083	24	45	
Riang	403	-	-	-		-	-	-		250	10	25		492	10	49	
Total	18,443	10,840	135	80		14,350	155	93		23,700	294	81		35,440	374	95	

C. PROJECTIONS FOR SERVED POPULATION

Served population in the BAN-WD has been projected to increase significantly in the next two decades. The increase will be a result of:

a) the intense campaign of the BAN-WD to connect and reconnect as many customers as possible;
b) the desire of residents in the BAN-WD to partake of the benefits of modern piped water system;
c) the increase in population in predominantly urban areas as well as in the geographical coverage of the BAN-WD.

Table VI-2 shows the detailed breakdown of the projected served population for the poblaciones of Bangued and Peñarrubia and the barrios within the future service area. Figure VI-2 shows the served population will triple from 1980 to 2000. The present service area will have a more rapid growth in served population than the future service area extension. Generally, the increase in the total served population would be greater in 1990-2000 than in 1980-1990. The served population projections are summarised as follows:

Year	Served Population	Population in the Service Area	Percent Served
1975 (Present)	6,720	10,840	62
1980 (Immediate)	10,120	14,350	71
1990	18,390	23,700	78
2000	30,020	35,440	85

D. WATER DEMAND PROJECTIONS

The water demand of the BAN-WD is 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 percent of production), have been estimated for the years 1980, 1990 and 2000 for the service area. Based on analyses (see Methodology Memorandum No. 3), BAN-WD has been classified under Group IV, with the following water use parameters:

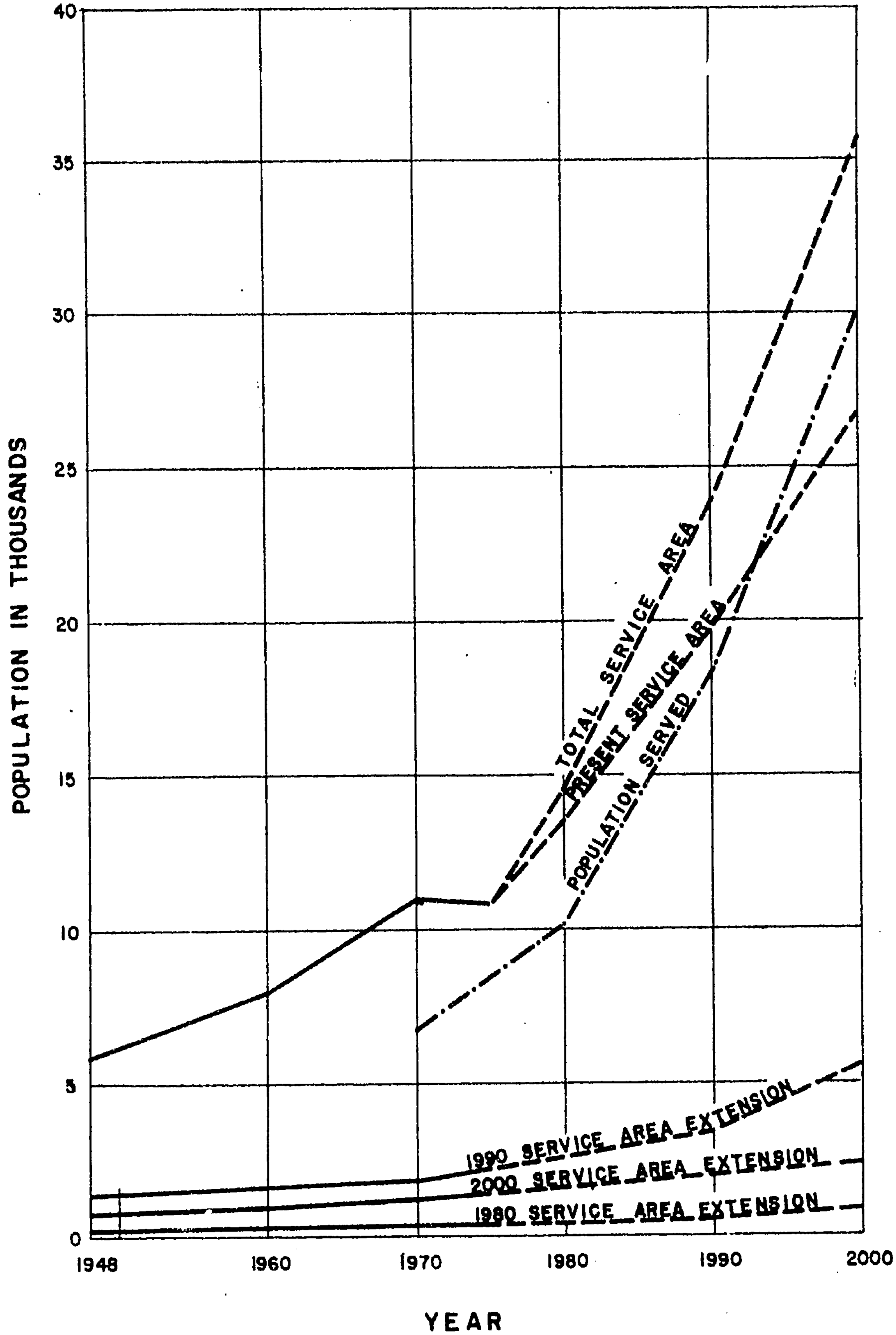


FIGURE VI-2
POPULATION PROJECTION
BANGUED WATER DISTRICT

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

TABLE VI-2

SERVED POPULATION PROJECTIONS
BANGUED WATER DISTRICT

		Present Service Area	(1980) Immediate Service Area	1990 Service Area	2000 Service Area
I.	Bangued (Poblacion)				
	A. Population in Service Area	10,135	11,968	16,880	22,688
	B. Number of Service Connections	790	1,090	1,752	2,552
	C. Connected Population	6,320	8,720	14,015	20,420
	D. % Connected	62%	73%	83%	90%
II.	Lipcan				
	A. Population in Service Area	319	740	1,120	1,637
	B. Number of Service Connections	37	97	169	263
	C. Connected Population	195	515	900	1,395
	D. % Connected	61%	70%	80%	85%
III.	Peñarrubia (Poblacion)				
	A. Population in Service Area	264	694	1,035	1,325
	B. Number of Service Connections	18	65	141	221
	C. Connected Population	85	312	675	1,060
	D. % Connected	33%	45%	65%	80%
IV.	Dumayco				
	A. Population in Service Area	122	570	755	1,083
	B. Number of Service Connections	23	60	99	164
	C. Connected Population	120	318	530	870
	D. % Connected	98%	56%	70%	80%
V.	Dangdangla				
	A. Population in Service Area	-	378	520	835
	B. Number of Service Connections	-	50	76	131
	C. Connected Population	-	255	390	670
	D. % Connected	-	67%	75%	80%
VI.	Riang				
	A. Population in Service Area	-	-	250	492
	B. Number of Service Connections	-	-	26	68
	C. Connected Population	-	-	150	395
	D. % Connected	-	-	60%	80%
VII.	Calaba				
	A. Population in Service Area	-	-	1,490	2,081
	B. Number of Service Connections	-	-	135	265
	C. Connected Population	-	-	745	1,455
	D. % Connected	-	-	50%	70%

TABLE VI-2 (Continued)

		Present Service Area	(1980) Immediate Service Area	1990 Service Area	2000 Service Area
VIII.	Bangbangar				
	A. Population in Service Area	-	-	585	1,122
	B. Number of Service Connections	-	-	55	141
	C. Connected Population	-	-	350	900
	D. % Connected	-	-	60%	80%
IX.	Patucannay				
	A. Population in Service Area	-	-	1,065	1,703
	B. Number of Service Connections	-	-	120	257
	C. Connected Population	-	-	635	1,365
	D. % Connected	-	-	60%	80%
X.	Agtañgao				
	A. Population in Service Area	-	-	-	957
	B. Number of Service Connections	-	-	-	105
	C. Connected Population	-	-	-	575
	D. % Connected	-	-	-	60%
XI.	Sao-atan				
	A. Population in Service Area	-	-	-	453
	B. Number of Service Connections	-	-	-	51
	C. Connected Population	-	-	-	275
	D. % Connected	-	-	-	61%
XII.	Palao				
	A. Population in Service Area	-	-	-	1,064
	B. Number of Service Connections	-	-	-	114
	C. Connected Population	-	-	-	640
	D. % Connected	-	-	-	60
	Total Number of Connections	868	1,362	2,573	4,332
	Total Population	10,840	14,350	23,700	35,440
	Total Population Served	6,720	10,120	18,390	30,020
	% Served Population	62%	71%	78%	85%

	1980	1990	2000
Domestic use, lpcd	95	110	125
Commercial/industrial/institutional, lpcd	12	15	20
Accounted-for-water, lpcd	107	125	145
Percentage of unaccounted-for-water, lpcd	(40)	(28)	(20)
Unaccounted-for-water, lpcd	71	49	36
Total Water Demand, lpcd	178	174	181

Present unaccounted-for-water of the BAN-WD (83.5 percent of total water production) is projected to be reduced to 40 percent by 1980. The factors that will contribute to the decline in unaccounted-for-water are: (1) initiation of an extensive leakage detection survey and repair; (2) metering of all existing connections; and (3) replacement of existing leaking connections.

Based on 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):

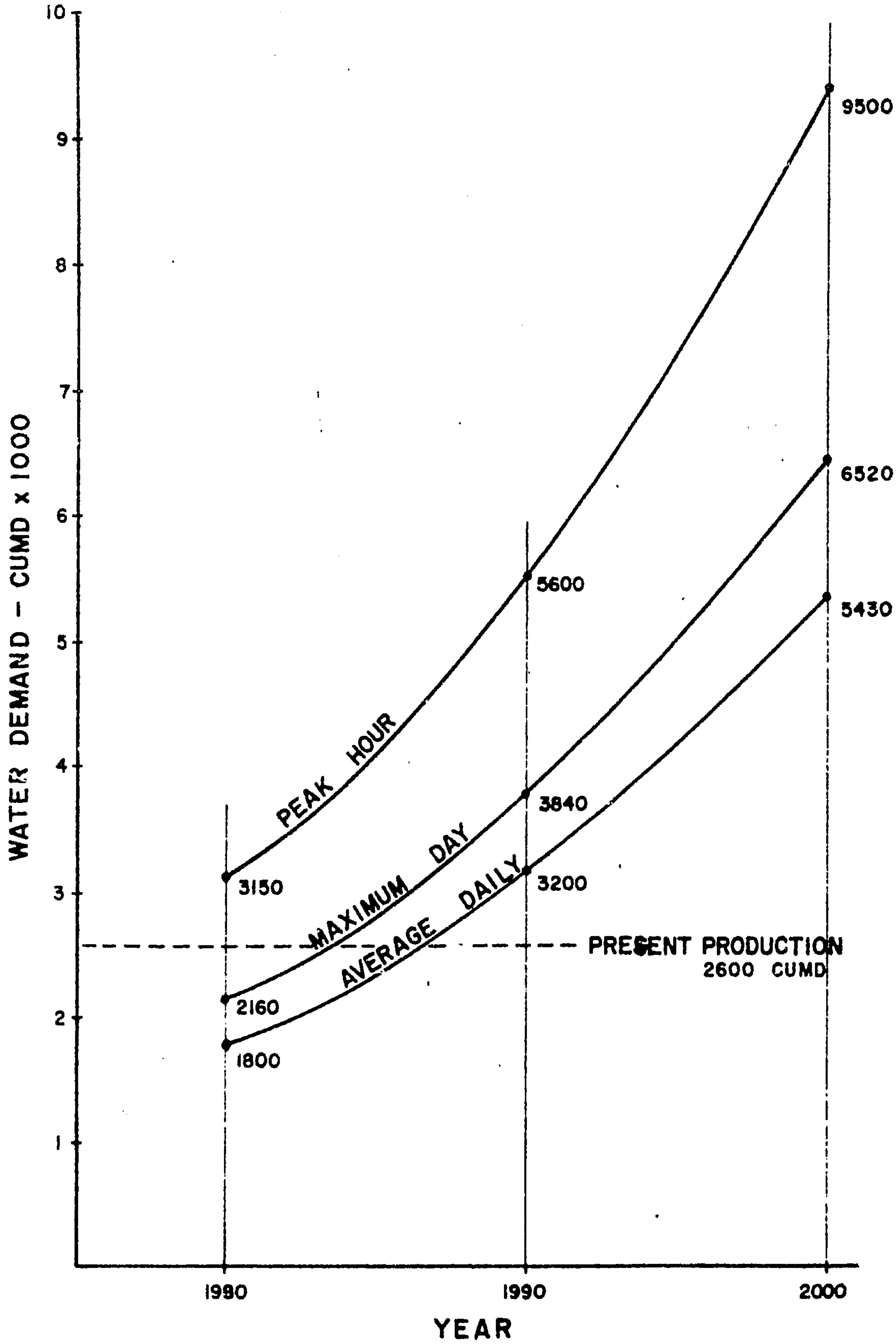
	1980	1990	2000
Water demand, lpcd	178	174	181
Served population	10,100	18,400	30,000
Average daily water demand, cumd	1,800	3,200	5,430
Maximum-day water demand[3/], cumd	2,160	3,840	6,520
Peak-hour water demand[4/], cumd	3,150	5,600	9,500

[3/] Based on 1.2 times average daily demand.
[4/] Based on 1.75 times average daily demand.

TABLE VI-3

YEAR-BY-YEAR SERVED POPULATION AND WATER DEMAND PROJECTIONS
BANGUED WATER DISTRICT

Year	Total Population Served	Average-Day Demand (cumd)	Maximum-Day Demand (cumd)	Peak-Hour Demand (cumd)
1978	8,590	1,990	2,390	3,480
1979	9,320	1,820	2,180	3,190
1980	10,120	1,800	2,160	3,150
1981	10,740	1,910	2,290	3,340
1982	11,400	2,020	2,420	3,540
1983	12,100	2,140	2,570	3,750
1984	12,850	2,270	2,720	3,970
1985	13,640	2,400	2,880	4,200
1986	14,480	2,540	3,050	4,450
1987	15,370	2,690	3,230	4,710
1988	16,300	2,850	3,420	4,990
1989	17,320	3,020	3,620	5,290
1990	18,390	3,200	3,840	5,600
1991	19,310	3,370	4,040	5,900
1992	20,280	3,560	4,270	6,230
1993	21,300	3,750	4,500	6,560
1994	22,370	3,950	4,740	6,910
1995	23,490	4,170	5,000	7,300
1996	24,670	4,400	5,280	7,700
1997	25,910	4,630	5,560	8,100
1998	27,210	4,890	5,870	8,560
1999	28,590	5,150	6,180	9,000
2000	30,020	5,430	6,520	9,500



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

FIGURE VI-3
PROJECTED WATER DEMAND
BANGUED WATER DISTRICT

CHAPTER VII WATER RESOURCES

A. GENERAL

The BAN-WD currently obtains all of its water from Lusuac Spring in the mountains to the southeast. The possible sources of water for further municipal supply are springs, wells, and surface water from the Abra River.

B. GROUNDWATER RESOURCES

The BAN-WD is located in the valley of the Abra River and in the adjacent hills to the southeast along the existing pipeline to Lusuac Spring. Lusuac Spring supplies the water district by gravity flow. The existing water distribution system is insufficient for the needs of the served communities and is supplemented by numerous, small-capacity private wells and by use of local surface water.

Lusuac Spring is capable of supplying all the requirements of Bangued by gravity flow beyond the year 2000. Wells are an alternate possible groundwater source and are also capable of supplying Bangued throughout the study period.

Geology

The hills flanking the Abra River in the Bangued area are composed of late Tertiary marine sediments, tuffaceous clastic rocks and limestones. Judging from outcrops to the east, the underlying basement rocks are metamorphased volcanics of Cretaceous or Early Tertiary age intruded by Tertiary andesitic rocks. The broad floodplain of the Abra River is filled with Recent alluvium; gravels, sands, silts and clays. The thickness of the alluvium is unknown, the deepest local wells penetrating it to about 50 meters.

The regional topography in the Bangued area is much affected by faulting, with the Abra River occupying a graben trending northeast - southwest about 45 degrees from the north - south regional structural trend of the Cordillera Central to the east. Bangued poblacion lies on an abandoned floodplain terrace of the Abra River. No well logs are available from the poblacion but data from surrounding wells indicate that the Recent alluvium may be thin at this point.

Aquifers

There are two obvious aquifer systems in the area. The Recent alluvium occupying the Abra River valley forms the better aquifer system. Based on limited well log data and surface examination, it consists of uncemented, intricately interbedded clays, silts, sands and gravels with great lateral variation over short distances. Local wells producing from this alluvium have poor specific capacities and are of low productivity but this is believed to result from poor well design and construction. This aquifer should have a high transmissivity and be very productive in those locations where clean, coarse sediments predominate. Abundant recharge to the valley alluvium will be provided by infiltration from the Abra River to replace any water pumped by BAN-WD.

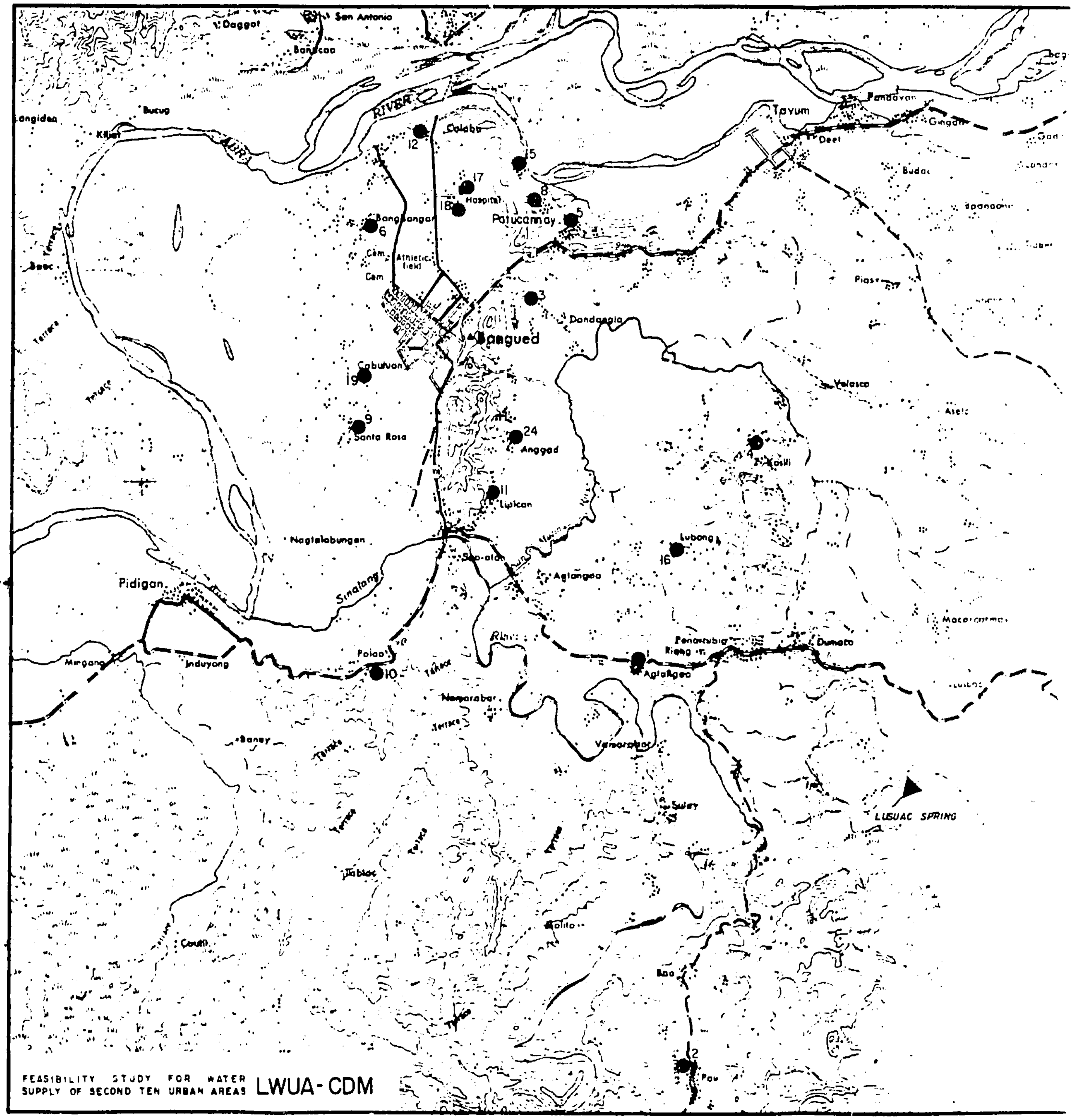
The other aquifer system is that of the older sediments beneath and in the hills surrounding Bangued. These same rocks underly the alluvium of the Abra floodplain. The older sediments are, in general, less porous and permeable than the Recent alluvium and, consequently, will not sustain highly productive wells. However, some beds in this aquifer system are quite permeable as a result of intergranular porosity, solution cavities, or fracture porosity and are responsible for numerous large springs in the region. Recharge to the aquifer system by infiltration of rainfall is inhibited by surface clays in many areas.

Springs

Springs occur whenever an aquifer is intersected by the land surface or whenever a natural conduit extends to the land surface from an aquifer with enough hydraulic head to force the water out. Springs are common in areas of high water table, either from a fully saturated section or "perched" as a result of an underlying impervious bed, where erosion incises the land surface. Thus they tend to occur in gulleys or canyons and at the foot of steep slopes.

In the Bangued area, several large springs are known and small springs and seeps are fairly common. This situation is to be expected in an area of considerable topographic relief and some permeable beds. Lusuac Spring, located at about 200 meters altitude and about 8 km southeast of Bangued poblacion, supplies BAN-WD (Figure VII-1). No other large springs are known to be closer to Bangued.

Lusuac Spring occurs at a break in slope on the northwest face of a large ridge. The spring emerges from a limestone formation into an artificial pool built by the previous Bangued Water Department. Other smaller springs or seepages occur in the area, some obviously leaking from the built-up collection pool and others separate but probably coming from the same source bed. There is a very old earthen dam that is overgrown with large trees and ponds water several hundred meters from Lusuac Spring, indicating that the source area has been in use for a long time. The existing spring facilities


San Antonio
Daggot
Bangued
Tayum
Pandayan
Deet
Colaba
Hospital
Patucannay
Bangbangar
Athletic field
Cem
Dandanaia
Cabuluan
Santa Rosa
Anggad
Lubong
Sao-atan
Aglangao
Pidigan
Sinalang
Nagtalabungan
Induyong
Polao
Namarabar
Vanarabar
Dumaco
Velasco
LUSUAC SPRING
Tablac
Bolito
Baney
Lagidon
Bucug
Kilat
RIVER
ABRA
Terrace
Piasa
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FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS
LWUA-CDM

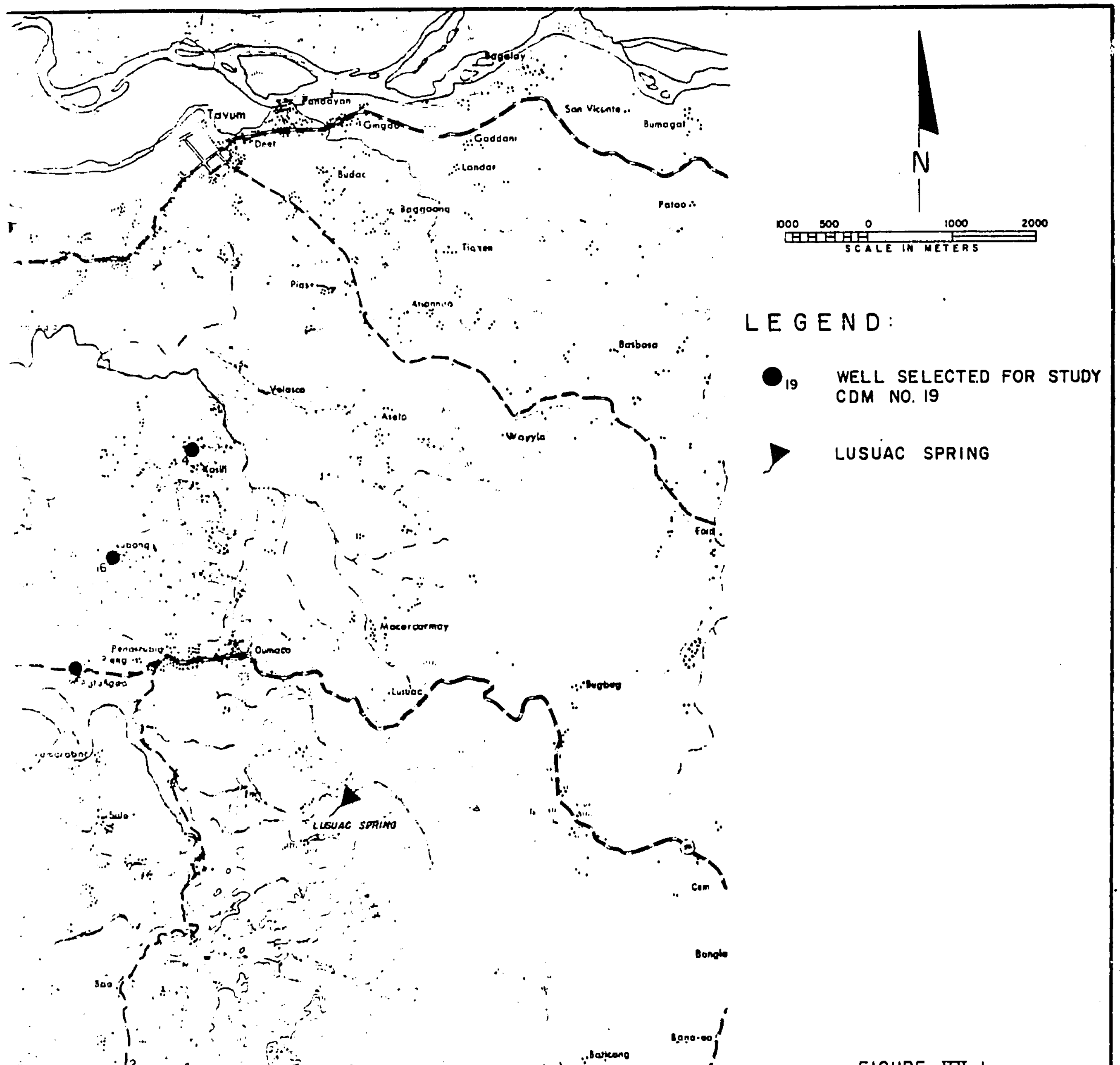

FIGURE VII-1
WELL LOCATION MAP
BANGUED, ABRA

are used by a small swimming pool at the spring site, for limited local irrigation, and as the BAN-WD source of supply. Most of the spring discharge flows to waste over a broad-crested weir.

A staff gage was installed at the weir and routine readings have been made of spring discharge with the irrigation diversion pipes plugged. The figures include some water from local seeps rather than from Lusuao Spring (approximately 2,600 cumd) and do not include the BAN-WD diversions (approximately 3,000 cumd rate). Thus, the figures probably represent the actual flow of Lusuao Spring within the limits of error of the measurements.

Date	Measured Flow - Lusuao Spring (cumd)
16 Sept 1976	25,000
21 Sept 1976	19,000
24 Sept 1976	20,000
28 Sept 1976	20,000
1 Oct 1976	22,000
8 Oct 1976	25,000
15 Oct 1976	25,000
22 Oct 1976	25,000
29 Oct 1976	25,000
5 Nov 1976	25,000
18 Mar 1977	19,000
25 Mar 1977	18,000

The flow is expected to decrease further in April but not significantly, considering the limited requirements of BAN-WD.

The total annual spring flow of Lusuao Spring alone appears to be about 7 million cubic meters. Most of the recharge from a very large area of hills above 200 meters altitude must be channelled to Lusuao Spring to sustain this flow. The topographic maps indicate a large sinkhole on the top of the ridge a kilometer south of the spring. The combined evidence of the sinkhole (karst topography), the large spring flow and the limestone outcrop at the spring implies that the large spring (and probably the other springs in the area) results from solution channels in a limestone formation. It further implies that the massive recharge necessary to sustain the springs results (at least in part) from infiltration and drainage into solution cavities in such a limestone. If the recharge area and storage volume supplying Lusuao Spring is in cavernous limestone, it is very likely that wet to dry season fluctuations of flow will be large because such limestones frequently release stored water very rapidly (high permeability and rapid drainage effect). Careful monitoring of spring flow throughout several years studied in conjunction with long-term precipitation records will be necessary to make a reasonable estimate of minimum flow. The minimum spring flow, however, appears to be much greater than the year 2000 requirements of BAN-WD.

Wells

There are numerous shallow, small-capacity handpump wells in Bangued poblacion that supplement the BAN-WD supply of domestic water. Numerous other handpump wells provide domestic water throughout the Bangued area. Records of depth, diameter and yield are available for 25 of these wells from the Bureau of Public Works (BPW). The pertinent data of these wells are given in Table VII-1 and the locations of most wells are shown in Figure VII-1. Stratigraphic logs are shown in Annex Figures VII-B-1 through VII-B-9. Unfortunately, the stratigraphic descriptions in the logs are too generalized for detailed study. In many cases, they do not even differentiate clearly those wells drilled in the Recent alluvium from those drilled in the older marine sediments (although adobe and limestone are considered to indicate the older rocks).

The following statistical data derived from the wells listed in Table VII-1 are pertinent:

1. Maximum test yield, 1.26 lps.
2. Average specific capacity, 0.26 lps/m, indicating generally poor wells incapable of large production.
3. Maximum specific capacity, 1.02 lps/m, however, the referenced well (CDM-17) was tested at such a small production rate (0.32 lps) that the figure is not particularly meaningful. The next lower specific capacity is 0.83 lps/m and the next two in order are both only 0.41 lps/m.
4. Maximum depth, 166.2 meters.
5. Average depth, 55.2 meters, with 4 wells over 100 meters. Average specific capacity of wells over the average depth is 0.16 lps/m, and of wells under the average depth is 0.30 lps/m, probably indicating that wells are drilled deep only in poorer aquifers.
6. Casing diameter varies from 37 to 150 mm, with no significant correlations with specific capacity.

An interpretation of existing well data must take into account that the wells are almost always poorly designed and constructed. They produce only from an open hole below the casing or from a short length of slotted pipe at the bottom of the casing. The well is drilled until the driller believes the well produce enough water for intended use from the bottom of the hole, and no attempt is made to

TABLE VII-1

WATER WELL DATA SUMMARY

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
1	4825	Agtañgao, Bangued	100	65.6	61.0	3.66	7.32	1.26	0.34	1949
2	4766	Pao, Bangued	100 75	105.2	31.4 49.7	9.76	11.59	0.63	0.34	1948
3	4875	Dangdangla, Bangued	100	105.8	44.8	3.05	11.89	0.63	0.07	1949
4	4931	Cosili, Bangued	100 75	166.2	62.8 99.4	15.24	33.53	0.63	0.03	1949
5	11284	Patucannay, Bangued	150	60.4	54.6	12.20	24.40	0.63	0.05	1956
6	8378	Bangbangar, Bangued	150	27.4	20.4	7.62	11.28	1.26	0.34	1955
7	11285	Macray, Bangued	150	54.9	49.7	10.67	24.39	0.63	0.05	1956
8	11283	Patucannay, Bangued	150	82.6	62.3	18.29	24.39	0.63	0.10	1956
9	11282	Santa Rosa, Bangued	150	25.3	25.1	10.67		0.95		1956
10	9946	Palao, Bangued	150	30.5	18.0	13.72	15.24	0.63	0.41	1956
11	9947	Lipcan, Bangued	150	39.9	24.7	12.20	15.24	0.63	0.21	1956
12	9945	Calaba North, Bangued	150	49.7	30.0	12.20	15.24	0.76	0.25	1956
13	16222	Sappaas, Bangued	112 100	51.9	13.7 23.8	3.66	3.96	0.63	0.19	1962
14	19542	Maoay, Bangued	100	30.8	30.8	12.20	15.24	0.63	0.21	1957
15	1606	Lingtaw, Bangued	100	47.3	40.9	12.57	16.77	0.05	0.01	1960
16	16011	Saguib Lubong, Bangued	100	19.5	19.2	3.05	4.57	0.63	0.41	1960
17	20901	PC Camp, Bangued	100	41.2	35.7	10.67	10.98	0.32	1.02	1958
18	20902	Abra Emergency Hospital, Bangued	37	47.3	18.8	9.15	10.67	0.32	0.21	1958
19	9943	Cabuluan, Bangued	150	17.7	14.6	10.67		0.76		1956
20	9941	Sacao, Bangued	75	28.1	12.2	9.15	10.67	1.26	0.83	1955
21	18742	Sapaac, Bangued	150	54.9	40.6	6.10	9.15	0.32	0.10	1958
22	16021	Palicao, Bangued	100	25.0	15.2	10.67	12.50	0.44	0.24	1960
23	9942	Sorcok, Bangued	150	109.8	67.1					1956
24	9948	Angad, Bangued	150	24.4	18.0	10.67	14.63	0.44	0.11	1956
25	1621	Bacsil I, Bangued		68.8	61.0	Abandoned				1962

produce from aquifer zones cased off in the upper well or to explore deeper to find more useable aquifer thickness. These properties are acceptable (but not desirable) for handpump wells,[1] but often result in uniformly poor wells (as illustrated in Table VII-1) whether the aquifers are very good, moderately poor or very variable. A very poor aquifer, of course, will support only very poor wells under any condition of well construction.

Thus, an analysis of the well data from Table VII-1 indicates only that wells producing at least a small amount of water can be drilled almost anywhere in the Bangued area. It is necessary to analyze the limited stratigraphic evidence from geologic maps, well logs and examination of surface exposures to estimate the probable productive capacity of good wells.

The Recent alluvium exposed in the active floodplain of the Abra River was examined. It appears to be largely fine to medium-grained sand with some silt, clay and scattered gravels. Well logs (Annex Figures VII-B-1 through VII-B-5) indicate a similar section with considerable local clay. The alluvium appears to be at least 30 meters thick in places and probably is considerably thicker in areas not yet tested. The alluvium underlying Bangued poblacion probably is quite thin as suggested by the logs (Annex Figures VII-B-1 through VII-B-4). The interference of thin alluvium underlying the poblacion is further substantiated by well water quality data in Table VII-2, page VII-12. One well shows excellent water quality, probably from the alluvium, while the other two produce considerably more saline water, probably from the older rocks. Wells of good design and construction drilled into this alluvium in areas where it is thick and where coarser sediments predominate should be fairly productive. Such wells are probably capable of yielding 20 lps or more at a specific capacity of 1 lps/m or more. Recharge and consequent maintenance of pumping levels will be no problem for wells drilled into the Abra River alluvium because well production will induce compensating additional infiltration from the river into the alluvium.

The aquifer system comprised of the older sediments of the hills will not be nearly as productive, on the average, as the Recent alluvium. Although some good wells might be constructed in locally permeable limestones or other locally occurring permeable zones; the general section as shown in the well logs (Annex Figures VII-B-6 through VII-B-9) implies a relatively poor aquifer containing much tuff (adobe). Wells of good design and construction in average areas probably would yield about 10 lps at a specific capacity of about 0.4 lps/m. Poorer wells are to be expected in many cases, and considerable exploratory drilling and testing will be necessary to

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[1] For further information on recommended practices for hand pump wells, see Appendix L, Volume II.

determine aquifer parameters and to delineate areas overlying good aquifer materials. A shortage of recharge is not a likely problem as long as well production does not greatly exceed the year 2000 requirements of BAN-WD.

Well Design and Drilling Program

It is necessary to develop a general well design and anticipated production parameters for wells in Bangued for purposes of economic studies of alternative sources for BAN-WD. If wells are chosen as water source, the ultimate design and production characteristics will be based on test drilling programs and may be considerably different from those used herein. However, the estimates herein are suitable for their purposes.

There are two distinctly different aquifer systems in the Bangued area and two different well designs are necessary. However, if it is decided to exploit either aquifer system, the drilling program would be similar. Small-diameter, stratigraphic exploration holes should be drilled, the first in the most convenient place (within the chosen aquifer area) for BAN-WD use and two or three more at a distance. If the geologic section in any or all of the wells appears suitable, these should be completed as test cum production wells. The well tests will provide aquifer data for use in refining the design of further wells. The wells can be drilled by either percussion or rotary methods, depending on available equipment, and can be either natural development or gravel-packed wells depending on aquifer conditions encountered. Suggested screen and casing sizes are 150 to 200 mm diameter lower casing and screen and 250 mm pump-housing casing for the first wells (suitable for 30 lps or less production rates). The casing sizes will be adjusted as the anticipated production rate of each well becomes more closely defined. Annex Figures VII-B-10 and VII-B-11 are examples of general well designs and construction suggestions for Bangued.

For cost estimating purposes, the following designs were used.

1. Induced infiltration wells in the Recent alluvium of the Abra River;
   a) Depth - 37 m
   b) Diameter of casing - 200 and 250 mm
   c) Production rate - 19 lps
   d) Pumping water level - 16 m below ground level
2. Deepwell in the older sediments;
   a) Depth - 92 m
   b) Diameter of casing - 150 and 250 mm
   c) Production rate - 6.3 lps
   d) Pumping water level - 25 m below ground level

It is anticipated, for purposes of cost estimation, that wells in Bangued poblacion will necessarily be deep wells because the alluvium will prove to be thin.

Monitoring

A monitoring program to gather water source data is necessary for proper planning and operation of any water district. In Bangued, Lusuac Spring production must be monitored and, if wells ever become an additional source, well production must also be monitored.

A permanent broad-crested weir already exists in the overflow channel of Lusuac Spring and a temporary staff gage has been erected to measure the head over the weir. The water channels in the area should be modified and maintained so that all the overflow, and only the overflow, from the spring passes over the weir. Furthermore the temporary gage should be replaced with a permanent installation and calibrated against weir overflow using a current meter, measuring flume or standard weir. Flow measurements should be made twice monthly, water samples for bacterial analysis should be collected monthly, and water samples for chemical analysis collected yearly. The collected data will give early warning of flow reduction or contamination so that remedial action can be taken early.

Each BAN-WD production well (if any) 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 kept. Water samples for bacterial analysis should be collected monthly and for chemical analysis, annually. The data from the well monitoring program will provide better aquifer parameters, indicate the magnitude of recharge, give early warning to BAN-WD of deterioration in water quality or pump performance so that remedial action can be taken, and show any unforeseen decline in regional water level so that individual well yields (which affect local pumping levels) and design and location of future wells can be adjusted as necessary. For these purposes, copies of all BAN-WD well monitoring data should be routinely analyzed by BAN-WD (if they have competent staff for such analyses) or by some associated agency competent to perform such analyses.

Summary of Groundwater Resources

Lusuac Spring is capable of supplying all of Bangued's water requirements past the year 2000 with good quality water requiring no treatment chlorination. It is high enough for water to be delivered to the entire water district by gravity flow, minimizing operating expenses and maintenance problems, but it is nearly 8 km from Bangued poblacion, requiring a long transmission pipeline. However, this pipeline also provides water to Peñarrubia Poblacion, only 2½ km from Lusuac Spring.

Wells can also be developed to supply the year 2000 requirements of Bangued with water requiring no treatment except chlorination. They would have the advantage of being closer to the poblacion and other centers of major use than Lusuac Spring is, but would have the disadvantage of requiring multiple pumping stations, with consequent operating costs and mechanical complexity.

Lusuac Spring has the additional advantage of being a certain source from a known location, making planning and design simple and estimated costs more accurate. The exact or even general location of wells to supply Bangued is currently uncertain; an elaborate exploration program would be necessary to positively identify the sites and thus permit detailed planning and design and defining costs.

C. SURFACE WATER RESOURCES

Bangued is situated in a large loop of the Abra River which has a reliable low flow much more than sufficient to provide all BAN-WD requirements beyond the year 2000. The Abra River is about 2 km from the center of the poblacion at its nearest point. Another possible Bangued surface water source is the Sinalang River, a tributary of the Abra River that passes a little more than 2 km south of the center of the poblacion at its nearest point where it leaves the hills. The Sinalang River at Bangued probably has a reliable low flow just sufficient to meet the year 2000 requirement for BAN-WD. Water from both rivers would require complete treatment to meet Philippine National Standards for Drinking Water.

Surface water data from rivers within the vicinity of Bangued have been compiled and analysed to establish the statistical recurrence of average and minimum monthly flows. BPW records of 4 gaging stations with monthly records spanning from 11 to 17 years were tabulated and analyzed using the Gumbel probability method of establishing 10-year, 5-year, and 1-year recurring flows (Methodology Memorandum No. 4). The analysis shows the following:

Station	Longitude/ Latitude	Years of Record	Drainage Area (sqkm)	Minimum Flow (cumd/sqkm) at Return Period of 10 Years	5 Years	1 Year
Sinalang River	120°-39'-20"					
@ Peñarrubia	17°-32'-20"	17	120	55	68	166
Abra River	120°-42'-40"					
@ Bo. Bumagoat	17°-37'-40"	17	2,575	362	397	561
Abra River	120°-28'-30"					
@ Bamaoang	17°-33'-20"	16	4,813	349	369	498

Abra River

Taking minimum recurring flows of the Abra River (for preliminary design purposes, "minimum flow" is taken as low flow that is statistically expected to occur once every 10 years); the flow ranges between 349 to 362 cumd/sqkm. On the basis that the drainage area of the Abra River in the proximity of Bangued is 4,430 sqkm, the theoretical minimum flow recurring once every 10 years will be 1.55 million cumd. This is obviously sufficient to provide the water supply requirements of BAN-WD for the year 2000.

The closest gaging station on the Abra River to Bangued is at Barrio Bumagoat, Tayum, about 10 km upstream of the Bangued poblacion. At this station, the minimum recorded flow was 0.91 million cumd. There is an irrigation pumping station of the National Irrigation Administration (NIA) on the Abra River at Barrio Bagalay, about 2 km downstream of the gaging station, but this station does not remove enough water to infringe on the quantity required by BAN-WD.

Sinalang River

Taking minimum recurring flows of the Sinalang River (10-year recurring minimum flows), the flow is statistically projected as 55 cumd/sqkm. On the basis that the drainage area of the Sinalang River in the proximity of Bangued is about 165 sqkm, the theoretical minimum flow recurring once every 10 years will be about 9,000 cumd, about 50 percent more than the year 2000 requirements of BAN-WD. The minimum recorded flow at the gaging station at Barrio Lungsad, Peñarrubia, about 8 km upstream of Bangued poblacion, was 6,050 cumd in March 1967.

D. WATER QUALITY OF POTENTIAL SOURCES

Water samples were taken from Lusuac Spring, the Abra River, and wells in the Bangued area. Chemical analyses were performed to determine the water quality of each potential source with respect to potability and treatment requirements. The results of these analyses are shown in Tables IV-2 and VII-2, and are briefly discussed below.

Lusuac Spring Water

Two analyses of water from Lusuac Spring are shown in Table IV-2. The water is of excellent chemical and physical quality and meets the requirements of the Philippine National Standards for Drinking Water in all respects. Even the hardness is relatively low for spring water in limestone country. The difference in the two analyses in regard to calcium and magnesium is almost certainly analytical error.

Well Water

Since groundwater essentially passes through a filtration process while flowing through a granular aquifer (such as in the BAN-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 existing Bangued wells are shown in Table VII-2. All of the well waters analyzed fall below the "excessive" limits of the Philippine National Standards for Drinking Water, and below the "permissible" limits in all respects, except for marginal hardness in one well sampled. However, the private well produces water of very low hardness, chloride content and sulfate content. This water almost certainly comes from the Recent alluvium which was deposited in fresh water and is so permeable as to be continually flushed by fresh recharge water. The other two wells produce considerably harder and more saline water almost certainly coming from the older sediments which are less permeable and more poorly flushed out and so contain either salts dissolved from the rocks or remnant traces of connate salt water.

TABLE VII-2

WATER QUALITY TEST RESULTS
POTENTIAL SOURCES
BANGUED WATER DISTRICT

Test	Unit	Permissible Limits	Abreco Compound Well, Bangued, Abra 25 March 1977	Public Market Site Well, Bangued, Abra 25 March 1977	Private Well Purugganan St. Corner Washington St. Bangued, Abra 25 March 1977	Abra River Bo. Calaba Abra 15 Sept 1976
Physical						
Color	APHA	15	2	2	2	110*
Turbidity	FTU	5	0	2	0	45*
Total Dissolved Solids**	mg/1	500	598	380	208	117
Conductivity	micromhos/cm.		920	585	320	180
Chemical						
pH		7-8.5	6.95	7.05	7.15	7.9
Total Alkalinity	mg/1 CaCO3		394	176	134	75
Phenolphthalein Alkalinity	mg/1 CaCO3		0	0	0	0
Total Hardness	mg/1 CaCO3	400***	414*	214	100	64
Calcium	mg/1	75	122*	56	25	24.8
Magnesium	mg/1	50	26	18	9	0.48
Total Iron	mg/1	0.3	0.08	0.30	0.22	0.9*
Fluoride	mg/1	1.5	0.43	0.43	0.50	0
Chloride	mg/1	200	76	84	7	2.44
Sulfate	mg/1	200	27	4	0	19
Nitrate ****	mg/1	50	13.5	5.8	10.6	8
Manganese	mg/1	0.1	0.06	0	0	0

*Exceeds the permissible limits set by the Philippine National Standards for Drinking Water.
**Computed to be 65 percent of conductivity.
***Limits inferred from limits of individual metals causing hardness.
****Fifty (50) to 100 mg/1 may cause infant disease according to Philippine National Standards for Drinking Water.

The water that would be produced from new BAN-WD wells can be expected to be similar to one of the tested well waters depending on the aquifer producing the water. Such water will almost certainly be acceptable for domestic use without extensive treatment.

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 and physical analyses performed on water from the Abra River are shown in Table VII-2. The results indicate that concentration of color and turbidity is excessive and treatment would be required particularly during the rainy season when turbidity would be much higher. The iron content is also excessive but dissolved iron in the reported quantity is unusual in normal aerated river water. The iron probably is particulate in nature and so would be readily filtered out during the otherwise required complete treatment.

ANNEX VII-B

WELL DATA

DESCRIPTIVE DATA

WELL NO. (CDM) 6
(OTHER) BPW 8378
LOCATION BARRIO BANGBANGAR
CITY BANGUED
PROVINCE ABRA
CONST. BY BPW
DRILLER
STARTED JUNE 8, 1955
COMPLETED JUNE 21, 1955
OWNER BPW
STATUS
CASING DIAMETER 150 MM. (6 IN.)
CASING LENGTH 20.4 M. (67 FT.)

DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL -7.6 M. (25 FT.)
PUMPING WATER LEVEL -20.4 M (37 FT.)
TEST PUMP YIELD 20 GPM (1.3 LPS)
SPECIFIC CAPACITY 0.3 LPS/M. (1.7 GPM/FT)

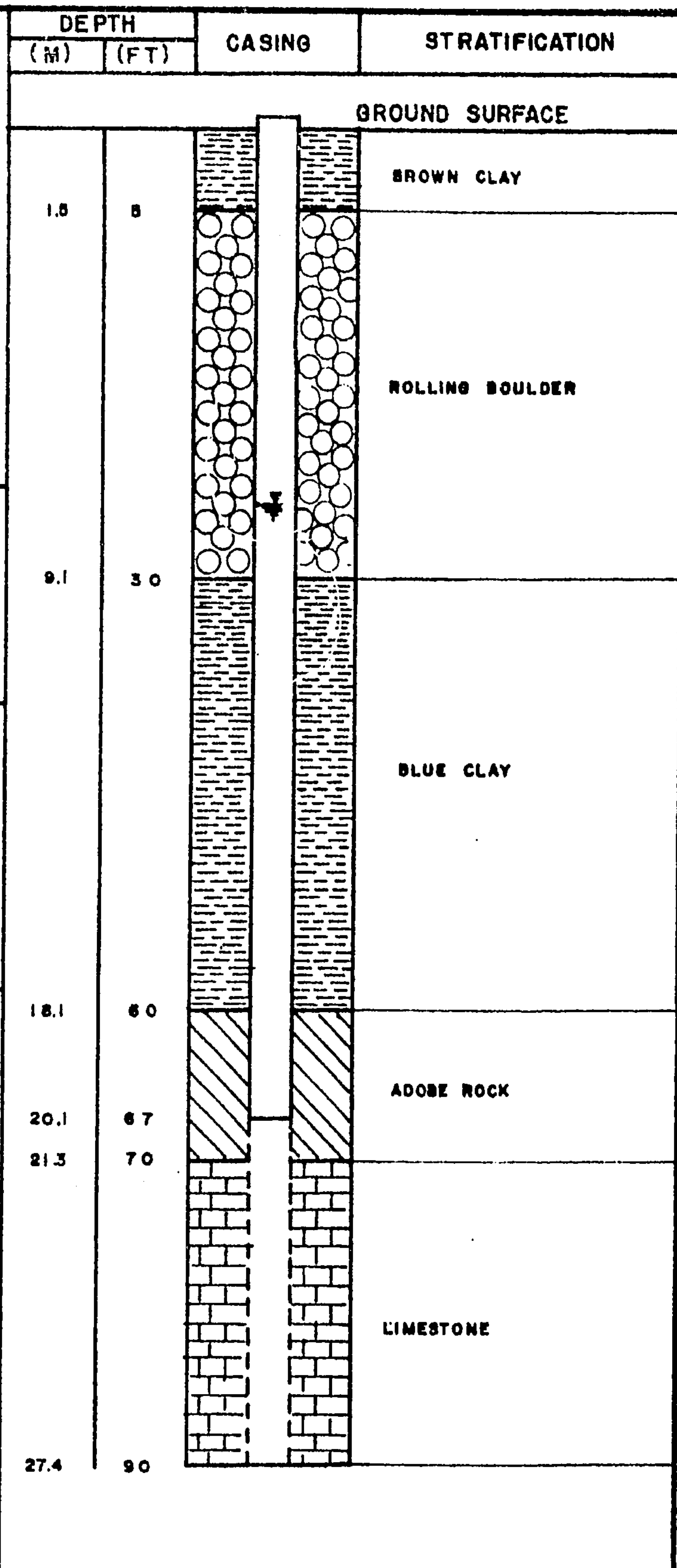
REMARKS

WATER BEARING STRATA
18.3 - 27.4 M. (60 - 90 FT.)

WATER QUALITY DATA:

WATER IS FRESH & CLEAR.

GRAPHIC LOG



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS

LWUA-CDM

ANNEX FIGURE VII-B-1
WELL DATA SHEET
WELL CDM-6

DESCRIPTIVE DATA

WELL NO.(CDM) 9
(OTHER) BPW NO. 11282
LOCATION BARRIO STA. ROSA
CITY BANGUED
PROVINCE ABRA
CONST.BY BPW
DRILLER DOMINGO ESCUDERO
STARTED APRIL 25, 1956
COMPLETED MAY 5, 1956
OWNER
STATUS
CASING DIAMETER 150 MM. (6 IN.) SUCTION
75 MM. (3 IN.)

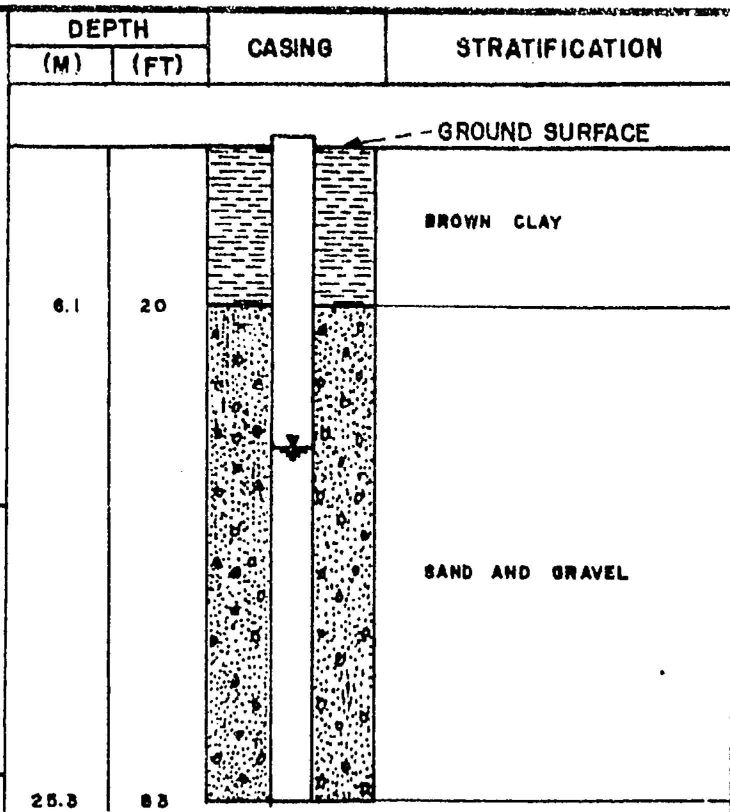
DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL - 10.7 M. (35 FT.)
PUMPING WATER LEVEL
TEST PUMPYIELD 0.95 LPS (15 GPM)
SPECIFIC CAPACITY

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG



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

ANNEX FIGURE VII-B-2
WELL DATA SHEET
WELL CDM-9

DESCRIPTIVE DATA

WELL NO. (CDM): 12
(OTHER): 9945
LOCATION: CALABA NORTH
CITY: BANGUED
PROVINCE: ABRA
CONST. BY:
DRILLER: CANDIDO SALUDARES
STARTED: APRIL 7, 1956
COMPLETED: JUNE 13, 1956
OWNER:
STATUS:
CASING DIAMETER: 150 MM (6 IN.) SUCTION: 75 MM (3 IN.)

DRILLER'S TEST DATA:

DATE:
STATIC WATER LEVEL: – 12.2 M (40 FT.)
PUMPING WATER LEVEL: – 15.2 M. (50 FT)
TEST PUMP YIELD: 0.76 LPS (12 GPM)
SPECIFIC CAPACITY: 0.25 LPS/M

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG

DEPTH (M)	DEPTH (FT)	STRATIFICATION
		GROUND SURFACE
		RED CLAY
5.2	17	RED CLAY WITH BOULDERS
6.1	20	RED AND YELLOW CLAY WITH BOULDERS
10.7	35	LOOSE ROCKS WITH CLAY
11.6	38	YELLOW CLAY WITH BOULDERS
12.8	42	SOLID ROCK
20.1	66	SAND AND GRAVEL
29.9	98	ADOBE STONE
36.9	121	SANDSTONE
49.7	163	

ANNEX FIGURE VII-B-3
WELL DATA SHEET
WELL CDM-12

DESCRIPTIVE DATA

WELL NO. (CDM) 17
(OTHER) 20901
LOCATION P.C. CAMP
CITY BANGUED
PROVINCE ABRA
CONST. BY
DRILLER AGAPITO GALICINAO
STARTED AUGUST 30, 1958
COMPLETED OCTOBER 10, 1958
OWNER
STATUS
CASING DIAMETER 100 MM. (4 IN.)
CASING LENGTH 35.7 M. (117 FT.)

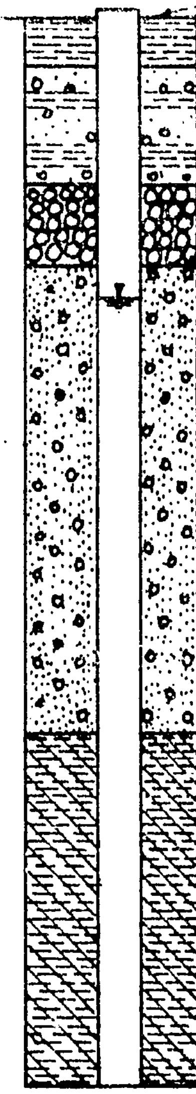
DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL − 10.7 M. (35 FT.)
PUMPING WATER LEVEL − 11.[illegible] M. (35 FT.)
TEST PUMP YIELD 0.32 LPS (5 GPM)
SPECIFIC CAPACITY 1.0[illegible] LPS/M.

REMARKS:

WATER QUALITY DATA

GRAPHIC LOG



DEPTH (M)	DEPTH (FT)	STRATIFICATION
		GROUND SURFACE
		BROWN CLAY
1.5	5	
		CONGLOMERATE
6.1	20	
		BOULDERS
9.1	30	
		SAND AND GRAVEL
27.4	90	
		ADOBE CLAY
41.2	135	

ANNEX FIGURE VII-B-4
WELL DATA SHEET
WELL CDM-17

DESCRIPTIVE DATA	
WELL NO. (CDM)	19
(OTHER)	9943
LOCATION	BARRIO CABULUAN
CITY	BANGUED
PROVINCE	ABRA
CONST. BY	
DRILLER	CASTOR MENDOZA
STARTED	APRIL 6, 1956
COMPLETED	APRIL 30, 1956
OWNER	
STATUS	
CASING DIAMETER	150 MM. (6 IN.) 75 MM (3 IN)
CASING LENGTH	

DRILLER'S TEST DATA:

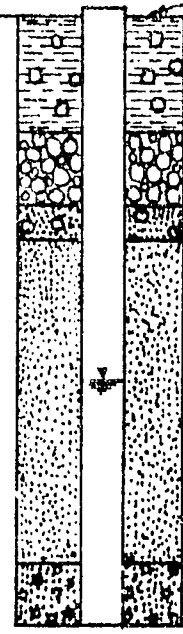
DATE	
STATIC WATER LEVEL	- 10.7 M. (35 FT.)
PUMPING WATER LEVEL	
TEST PUMP YIELD	0.76 LPS (12 GPM.)
SPECIFIC CAPACITY	

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG

DEPTH (M)	DEPTH (FT)	STRATIFICATION
		GROUND SURFACE
3.4	11	BROWN CLAY WITH BOULDERS
5.5	18	BOULDERS AND GRAVEL
6.4	21	BOULDERS, SANDSTONE
15.9	52	SANDSTONE
17.7	58	SAND AND GRAVEL



ANNEX FIGURE VII-B-5
WELL DATA SHEET
WELL CDM-19

DESCRIPTIVE DATA

WELL NO. (CDM) 2
(OTHER) BPW 4766
LOCATION BARRIO PAO
CITY BANGUED
PROVINCE ABRA
CONST. BY
DRILLER BONIFACIO DE LA CRUZ
STARTED OCTOBER 5, 1948
COMPLETED DECEMBER 1, 1948
OWNER
STATUS
CASING DIAMETER 100 MM. (4 IN.)
31.4 M. (-103 FT.) 76 MM. (3 IN.)
18.3 M. (-60 FT.)

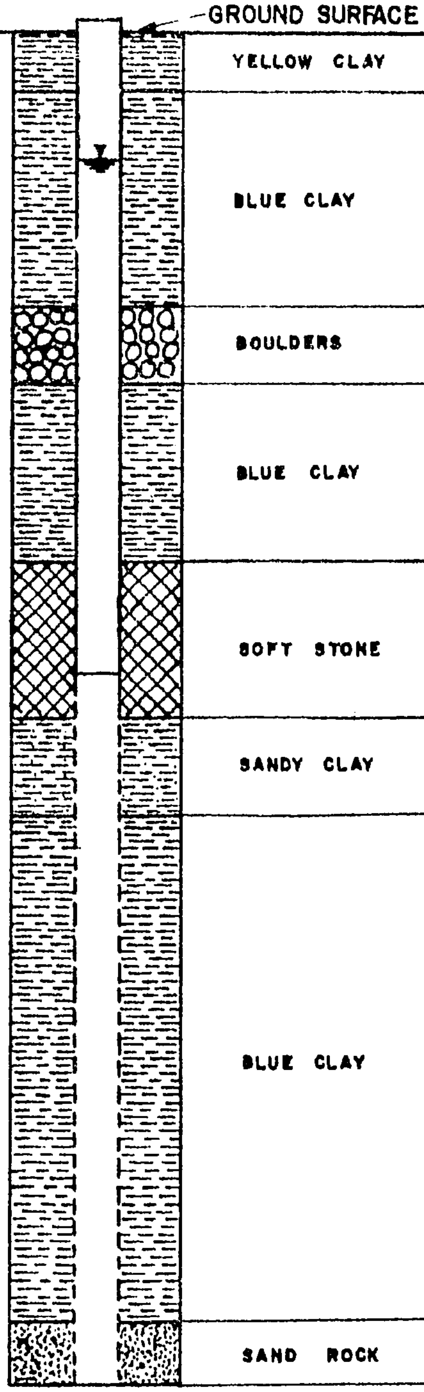
DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL -9.0 M. (32 FT.)
PUMPING WATER LEVEL -11.6 M (38 FT.)
TEST PUMP YIELD 10 GPM (0.6 LPS)
SPECIFIC CAPACITY 0.3 LPS/M (1.6 GPM/FT.)

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG



DEPTH (M)	DEPTH (FT)	STRATIFICATION
		YELLOW CLAY
4.6	15	BLUE CLAY
21.3	70	BOULDERS
27.4	90	BLUE CLAY
41.1	135	SOFT STONE
49.7	163	
53.5	175	SANDY CLAY
61.0	200	BLUE CLAY
100.6	330	SAND ROCK
105.1	345	

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS

LWUA-CDM

ANNEX FIGURE VII-B-6
WELL DATA SHEET
WELL CDM-2

DESCRIPTIVE DATA

WELL NO. (CDM) 4
(OTHER) BPW 4931
LOCATION BARRIO COSILI
CITY BANGUED
PROVINCE ABRA
CONST. BY BPW
DRILLER
STARTED FEBRUARY 22, 1949
COMPLETED APRIL 13, 1949
OWNER BPW
STATUS
CASING DIAMETER 100 MM (4 IN.) - 62.8 M. (206 FT.)
76 MM (3 IN.) - 36.6 M. (120 FT.)

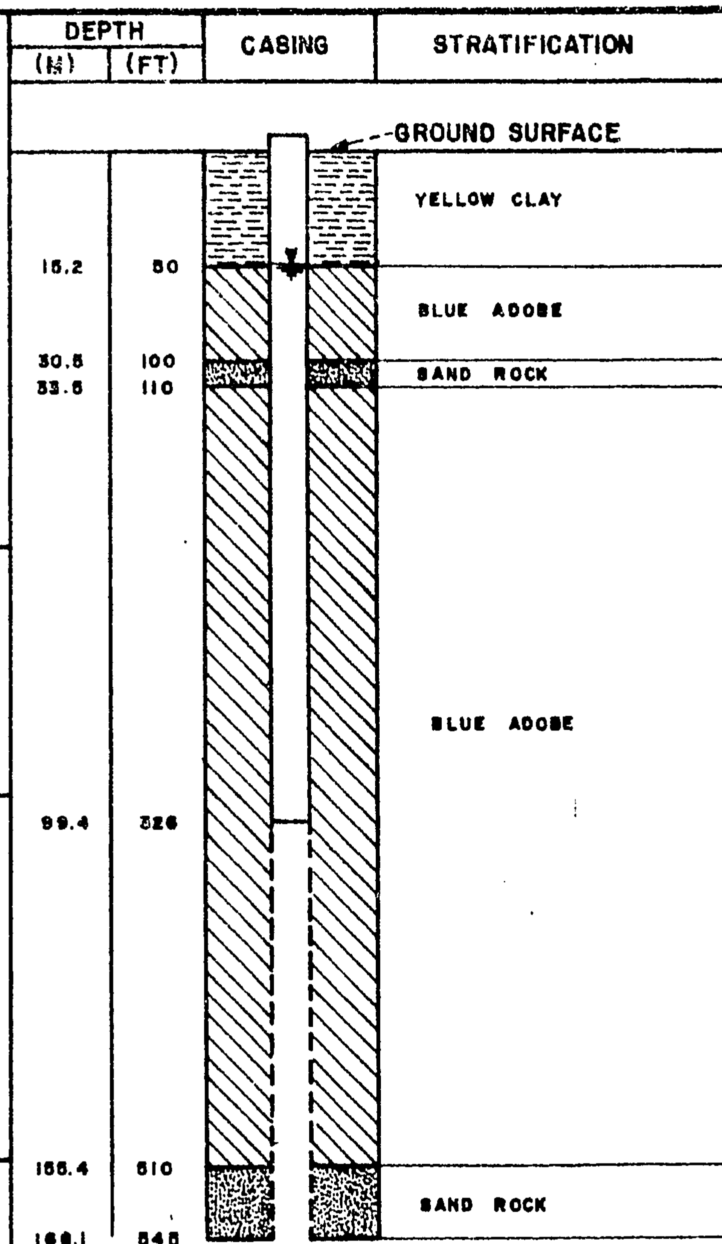
DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL -15.2 M. (50 FT.)
PUMPING WATER LEVEL -33.5 M. (110 FT.)
TEST PUMP YIELD 10 GPM (0.6 LPS)
SPECIFIC CAPACITY 0.03 LPS/M (0.2 GPM/FT.)

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS

LWUA-CDM

ANNEX FIGURE VII-B-7
WELL DATA SHEET
WELL CDM-4

DESCRIPTIVE DATA

WELL NO. (CDM) 5
(OTHER) BPW 11284
LOCATION BARRIO PATUCANNAY
CITY BANGUED
PROVINCE ABRA
CONST. BY BPW
DRILLER
STARTED MAY 19, 1956
COMPLETED MAY 27, 1956
OWNER BPW
STATUS
CASING DIAMETER 150 MM. (6 IN.)
CASING LENGTH 54.5 M. (179 FT.)

DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL - 12.2 M. (40 FT.)
PUMPING WATER LEVEL - 24.4 M. (80 FT.)
TEST PUMP YIELD 10 GPM (0.6 LPS)
SPECIFIC CAPACITY .05 LPS/M (0.25 GPM/FT)

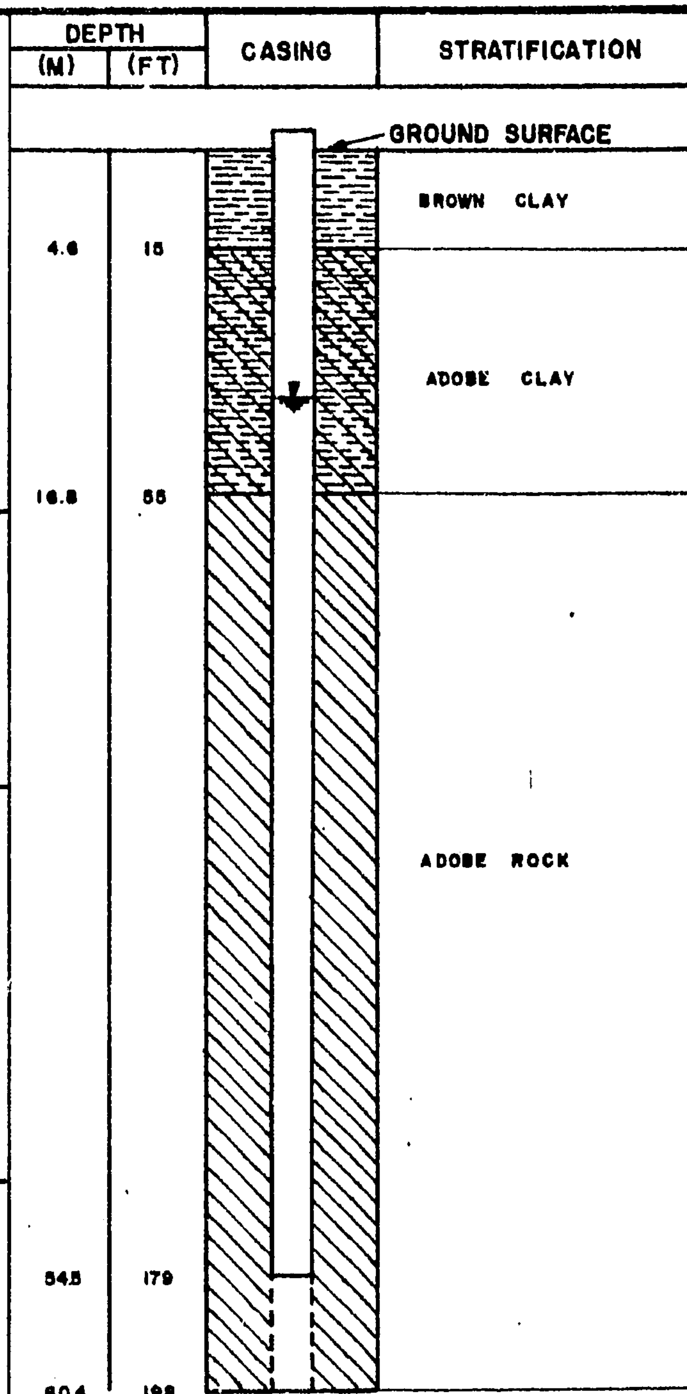
REMARKS:

WATER BEARING STRATUM AT 55-198 FT. (16.8 - 60.4 M.)

WATER QUALITY DATA:

WATER IS CLEAR.

GRAPHIC LOG



ANNEX FIGURE VII-B-8
WELL DATA SHEET
WELL CDM-5

DESCRIPTIVE DATA

WELL NO. (CDM) 10
(OTHER) 9946
LOCATION PALAO
CITY BANGUED
PROVINCE ABRA
CONST. BY
DRILLER CANDIDO GONZALES
STARTED JUNE 4, 1956
COMPLETED JUNE 27, 1956
OWNER
STATUS
CASING DIAMETER 150 MM (6 IN.)
CASING LENGTH 18 M. (59 FT)

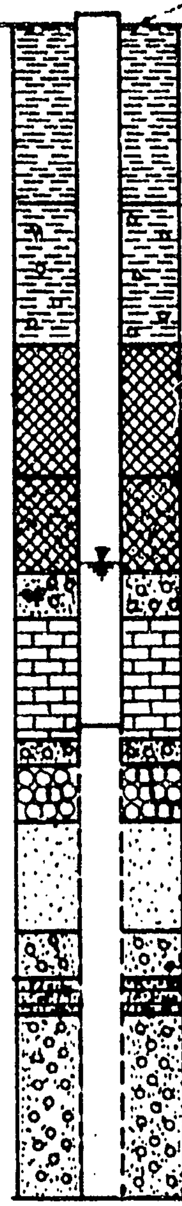
DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL -13.7 M. (45 FT.)
PUMPING WATER LEVEL -15.2 M. (50 FT.)
TEST PUMP YIELD 10 GPM (0.63 LPS)
DURATION OF TEST 18 HOURS
SPECIFIC CAPACITY 0.42 LPS/M (2GPM/FT.)

REMARKS

WATER QUALITY DATA:

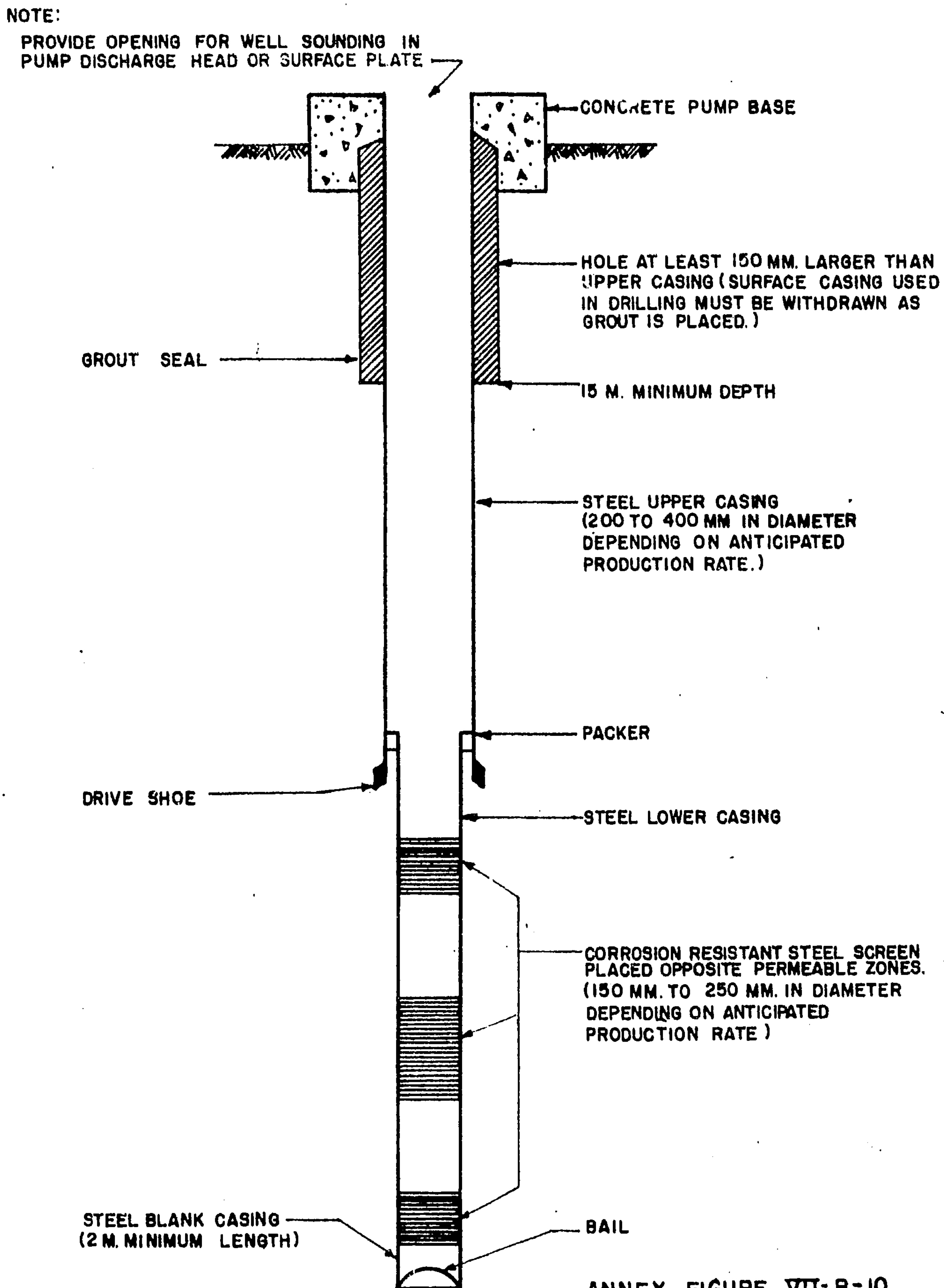
GRAPHIC LOG



DEPTH (M)	DEPTH (FT)	STRATIFICATION
		GROUND SURFACE
		BROWN CLAY
4.6	15	
		BROWN CLAY WITH LOOSE ROCKS
8.2	27	
		DEAD ROCK*
11.6	38	
		DEAD ROCK* WITH QUICK SAND
14.0	46	
		SAND AND GRAVEL
15.2	50	
		LIMESTONE
18.3	60	
		SAND AND GRAVEL
18.9	62	
		BOULDERS
20.4	67	
		SANDSTONE
23.2	76	
		SAND AND GRAVEL
24.4	80	
		LIMESTONE WITH SAND AND GRAVEL
25.3	83	
		SAND AND GRAVEL
30.5	100	

*LOCAL DRILLERS NON STANDARD TERMINOLOGY

ANNEX FIGURE VII-B-9
WELL DATA SHEET
WELL CDM-10



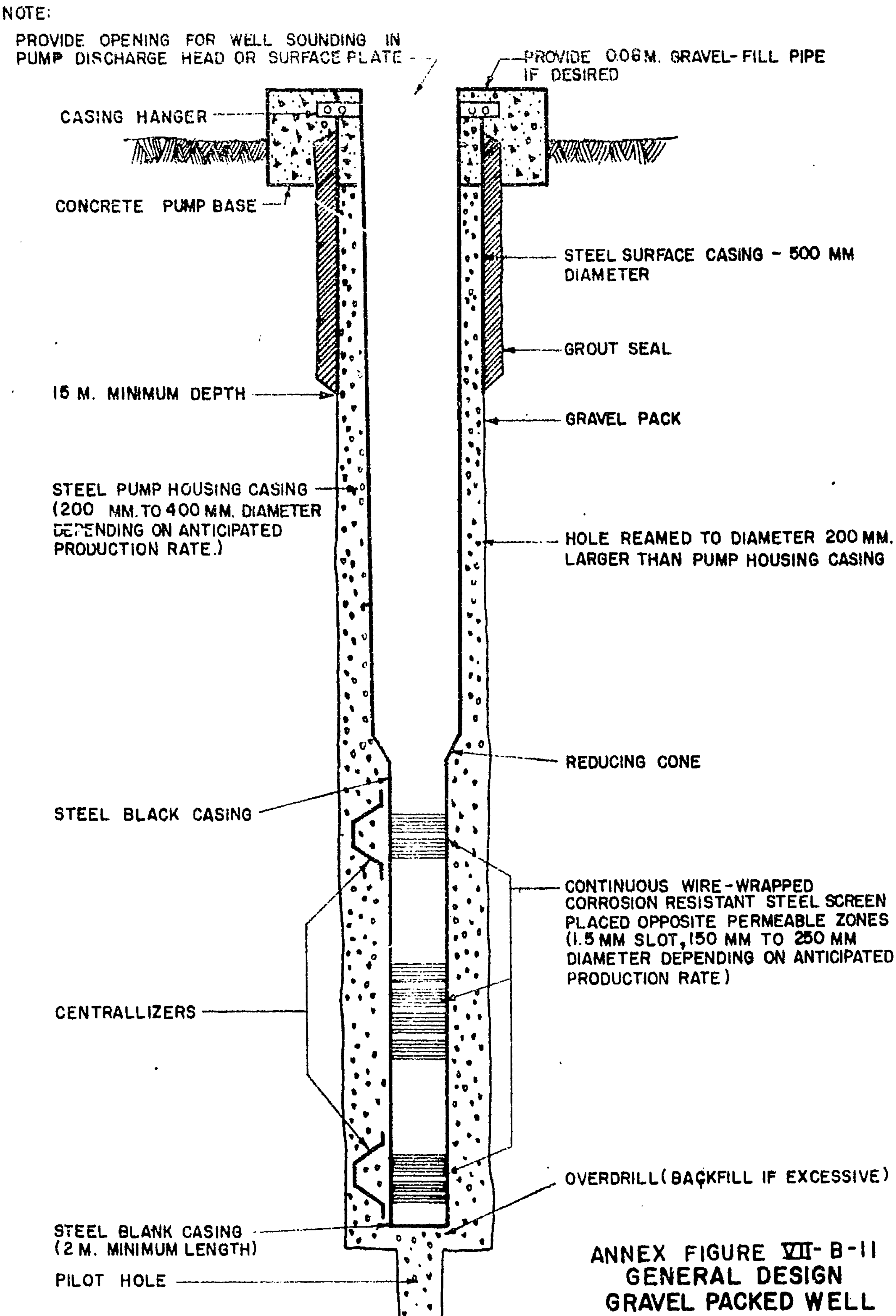
ANNEX FIGURE VII-B-10
GENERAL DESIGN
NATURAL DEVELOPMENT WELL
PERCUSSION DRILLED
BANGUED WATER DISTRICT

SUPPLEMENT TO ANNEX FIGURE VII-B-10

GENERAL CONSTRUCTION SUGGESTIONS

Natural Development Well - Percussion Drilled

1. Drive and drill surface casing to 15-meter depth, or more if conditions require.
2. Drive and drill upper casing to depth necessary to produce satisfactory well based on sample examination and knowledge of nearby wells. Collect careful samples and use no clay in drilling.
3. Examine samples to determine suitable permeable zones. Pull casing and abandon site if sufficient permeable material is not encountered.
4. Place a string of lower casing and screen sections on bottom of hole with screen sections opposite permeable zones.
5. Pull back upper casing to expose screen.
6. Develop and test well.
7. Design pump.
8. Construct well head facilities.
9. Install pump.



ANNEX FIGURE VII-B-11
GENERAL DESIGN
GRAVEL PACKED WELL
ROTARY DRILLED
BANGUED WATER DISTRICT

SUPPLEMENT TO ANNEX FIGURE VII-B-11

GENERAL CONSTRUCTION SUGGESTIONS

Gravel Packed Well - Rotary Drilled

1. Drill oversized hole to 15-meter minimum depth (more if conditions require), set and grout surface casing.
2. Drill pilot hole inside surface casing to anticipated maximum total depth.
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. Enlarge pilot hole diameter by reaming to a depth about 5 meters below lowest permeable zone. Diameter of reamed hole to be such that sufficient clearance is provided between bore-hole and pump housing casing for easy placement of gravel, but such that diameter of reamed hole is not more than 200 mm or 250 mm greater than diameter of well screen. If necessary, ream hole to 2 different diameters, the larger opposite the pump housing casing and the smaller opposite the screen.
6. Install string of casing and screen in reamed hole with screen opposite permeable zones.
7. Place gravel.
8. Develop and test well.
9. Design pump.
10. Construct well head facilities.
11. Install pump.

CHAPTER VIII ANALYSIS AND EVALUATION OF ALTERNATIVES

A. GENERAL

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

B. WATER SUPPLY SOURCE ALTERNATIVES

Surface Water Sources

A large perennial stream, the Abra River, is located about 2 km north of the north edge of Bangued. Water in the Abra River is more than sufficient to meet the needs of Bangued to the year 2000. The monthly mean flow is less than a million cumd only about once in 7 years at Barrio Bumagcat, 10 km above Bangued. The chemical quality of the Abra River is satisfactory, as shown in Table VII-2. The use of the Abra River as a source of water for Bangued is, therefore, technically feasible.

However, the use of the Abra River would entail construction of a diversion structure and low-lift pumps; complete water treatment works; and a second set of high-lift pumps to pump treated water to the distribution system. About the same volume of water could probably be obtained from induced infiltration wells at the same site. The use of surface water as a municipal supply by Bangued would be costlier than using induced infiltration wells since a well water supply would not require facilities for treatment and double pumping. Therefore, surface water could not be most economic source of water for Bangued, and has been eliminated as an alternative source of supply.

Groundwater Sources

An inspection of the banks of the Abra River near Bangued has found conditions reasonably favorable for the use of induced infiltration wells. A test well program would be necessary to precisely determine the depth and capacity of such wells. Pending the results of the test wells, induced infiltration wells are considered technically feasible as an alternative source of water for Bangued. The parameters suggested for cost analysis of infiltration wells are tabulated on page VII-7.

Although there are no large-capacity wells within Bangued, a number of small capacity hand pump wells, mostly 6 to 12 meters deep, are being used in the proposed service area. The alluvium underlying the BAN-WD is sufficiently pervious and water-bearing to indicate that moderate-sized wells may be constructed satisfactorily (see Chapter VII). If wells were considered, these conditions would have to be verified with test wells. Assuming that deep wells in this area will be moderately successful, the cost of supplying the BAN-WD service area with deep well water has been calculated for comparison with other alternative sources. The parameters suggested for cost analysis of deep wells are tabulated on page VII-7.

Springs

Since 1919, Bangued has been supplied with water piped from Lusuac Spring, 8 km away from the poblacion. The quality of the spring water is favorable for water supply (refer to Table IV-2). The flow from the spring has been measured several times weekly since September 1976 and has never been less than 3 times the estimated maximum-day water requirement of the BAN-WD in the year 2000 (see page VII-3). Lusuac Spring is therefore adequate for future supply.

Other springs in the area are not large enough for BAN-WD needs. These are situated at lower elevations and farther from the poblacion than Lusuac Spring. The cost of transmission from these springs would likely exceed that of Lusuac. Lusuac is therefore the preferable spring source, and is one of the alternatives considered.

Comparison of Alternatives

The economic comparison of the 3 source alternatives - induced infiltration wells, deep wells and Lusuac Spring - for the BAN-WD to the year 2000 conforms to the economic cost criteria in Appendix F. The cost of electric energy used is ₱0.41/kwh. The facilities for these alternatives would be constructed in stages. All 3 alternatives can meet the projected water demands shown in Figure VI-3. In the initial comparison, the present transmission lines from Lusuac Spring have been assumed to provide adequate water until 1983. The alternatives are therefore compared on the basis of their present worth cost to supply the additional water required by the BAN-WD between 1984 and 2000, assuming that the present transmission mains could continue to operate until the year 2000. Costs common to all alternatives are omitted from the comparison.

Comparative present worth costs of the 3 alternatives, under the above stated assumptions, are given in Table VIII-1. The comparative analysis of the present worth costs for supplying water to BAN-WD until the year 2000 indicates that the supply available from wells in the service area is the least costly of the 3 sources considered (about 13 percent less than the supply from Lusuac Spring). If the analysis is extended to the year 2010, on the same assumptions,

TABLE VIII-1

COMPARATIVE PRESENT WORTH COSTS OF ADDITIONAL SUPPLY ALTERNATIVES[1]

	Construction Cost (₱ x 1000)	Present Worth Cost[2] (₱ x 1000)
Induced Infiltration Wells on Abra River		
Wells and Pumphouses	₱1,794	519
Distribution Pipelines[3]	300	88
Transmission Pipelines	1,750	362
Operation and Maintenance	-	281
Total Present Worth Cost		₱1,250
Wells in Service Area		
Wells and Pumphouses	₱2,517	₱ 598
Distribution Pipelines[3]	-	-
Transmission Pipelines	-	-
Operation and Maintenance	-	235
Total Present Worth Cost		₱ 833
Lusuac Spring		
Wells and Pumphouses	-	-
Distribution Pipelines[3]	₱ 300	₱ 85
Transmission Pipelines	2,950	829
Operation and Maintenance	-	47
Total Present Worth Cost		₱ 961

1/ These alternatives are based on an estimated staging program. See Annex VIII-B for details.

2/ Includes salvage values and replacement costs.

3/ Cost for distribution pipelines only include those costs in excess of distribution costs of other alternatives.

the wells would still have the least present worth cost but only 7 percent less costly than that for Lusuac Spring. These differences are within, or at least near, the expected range of accuracy for such estimates.

A groundwater supply, under the assumed conditions, could provide additional water for BAN-WD at less cost than that from Lusuac Spring. However, the actual conditions may be different than the assumed conditions and that would not favor the ground water alternative. The quantity of ground water assumed available may not, in fact, be available. Moreover, it may not be economical to use the groundwater even if available. Water from wells appears to be less costly when required in small quantities to supplement the existing water system. If a large quantity of water is required from the well system at an early date due to failure of one of the existing transmission mains, the Lusuac Spring alternative would end up less costly. Table VIII-2 compares the present worth costs of supplying additional water to the BAN-WD on the assumption that one of the existing transmission mains would be replaced by 1984.

Evaluation of Alternative Sources

The first comparative analysis (Table VIII-1) shows that it will be less costly for Bangued to obtain its required additional water from wells in the service area under these conditions: (1) supply from such wells is feasible, and (2) the 2 existing transmission mains from Lusuac Spring could operate until about the year 2000.

The second comparative analysis (Table VIII-2) shows that water from Lusuac Spring is less costly than groundwater wells if one of the existing mains fails on or before 1984.

The quantity of water available from Lusuac Spring is quite certain, and based on field observations (see page IV-8) of the existing transmission mains, it is quite reasonable to expect the condition of one of the mains to deteriorate to a point where it should be abandoned by 1984. In either analysis, the deep well alternative is extremely dependent on the cost of power (maintenance and operation). Any future increases in fossil fuel costs would definitely favor the spring (gravity) alternative. Therefore, it is recommended that Lusuac Spring be utilized in the future as BAN-WD source of supply.

If at sometime in the future the spring supply is inadequate or the quality deteriorates, then it would be advisable to investigate utilizing wells for supply.

TABLE VIII-2

COMPARATIVE PRESENT WORTH COSTS OF ADDITIONAL SUPPLY ALTERNATIVES[4]
(Assuming one transmission main is abandoned by 1984)

	Construction Cost (₱ x 1000)	Present Worth Costs[5] (₱ x 1000)
Wells in Service Area		
Wells and Pumphouses	₱3,055	₱ 914
Distribution Pipelines[6]	-	-
Transmission Pipelines	-	-
Operation and Maintenance	-	538
Total Present Worth Cost		₱1,452
Lusuac Spring		
Wells and Pumphouses	-	-
Distribution Pipelines[6]	₱ 300	₱ 83
Transmission Pipelines	3,465	1,045
Operation and Maintenance	-	40
Total Present Worth Cost		₱1,168

[4] These alternatives are based on an estimated staging program. See Annex VIII-B for details.

[5] Includes salvage value and replacement costs.

[6] Costs for distribution pipelines only include those costs in excess of distribution costs of other alternatives.

C. TREATMENT ALTERNATIVES

The Lusuac Spring analysis (Table IV-2) shows that, except for total hardness and magnesium content, all chemical constituents are within the acceptable limits of the Philippine National Standards for Drinking Water. Hardness in domestic water supply is an economic problem since it results in waste of soap and encrustation of utensils. It is also undesirable for certain industrial processes such as carbonated beverages, metal finishing, food processing, textile industries and pulp and paper process. However, hardness has no demonstrable harmful effects on the health of consumers. Magnesium is considered relatively non-toxic to man and is not a public health hazard. At high concentrations, however, magnesium salts have a laxative effect, particularly with new consumers. The human body is able to develop a tolerance over high magnesium concentrations over a period of time.

The analysis of water from wells (Table VII-2) shows the water is within the acceptable limits of the Philippine National Standards for Drinking Water.

Therefore, water from Lusuac Spring and deep wells within the BAN-WD (the best and near best alternatives), if properly designed and constructed, would not require any treatment. However, in order to preserve the good quality of water throughout the distribution system, disinfection would be necessary at these sources. Disinfection may be accomplished by various methods which are discussed in Appendix J, Volume II. For economic and practical reasons (availability of the equipment, supply and application, and lasting effectiveness), chlorination is the recommended process for disinfection.

D. DISTRIBUTION ALTERNATIVES

General

This section presents the various distribution alternatives considered for the BAN-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 have been 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 is given to the requirements of fire flow for the BAN-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; therefore, relatively minor adjustments are required in the pipe system to provide fire flow. In the smaller communities, especially the small barrios some distance from the central 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 much greater than the ultimate peak demand is rarely economically justified; but some fire protection should be provided. In this study, information is given on the available fire flow at various locations where the system has been designed for conditions other than fire flow.

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

	1980	1990	2000
Water demand, lpcd	178	174	181
Served population	10,120	18,390	30,020
Average daily water demand, cumd	1,800	3,200	5,430
Maximum-day water demand, cumd	2,160	3,840	6,520
Peak-hour water demand, cumd	3,150	5,600	9,500

Pressure Zone

The ground elevation in the future service area of the BAN-WD to the year 2000 varies from a low of 38 meters just north of the poblacion to a high of 85 meters in Peñarrubia. The poblacion of Bangued is largely situated at an elevation of 40 meters.

There are essentially 2 pressure service areas in the existing Bangued water system. The pressures in Bangued are regulated by the water elevation in the existing storage tank, while the pressures in Peñarrubia are controlled by the hydraulic gradeline within the transmission mains from Lusuac Spring to Bangued.

The existing storage tank is not high enough to serve the Peñarrubia area effectively. In the future, Peñarrubia and the adjacent barrios of Dumayco and Riang should continue to be served directly from the transmission mains.

The hydraulic gradeline in the transmission mains between Lusuac Spring and Bangued is expected to be higher than necessary to serve the Peñarrubia area and adjacent barrios. The Peñarrubia area should therefore be served through a pressure-reducing valve from the transmission mains to reduce the average head from about 80 meters (7.7 atmospheres) to 41 meters (4 atmospheres). This would provide a more reasonable working pressure for the consumers in Peñarrubia.

The overflow elevation of the existing storage tank (101.6 meters) is sufficient to serve the poblacion of Bangued and the adjacent barrios expected to be served by the year 2000.

Storage Facilities

Storage facilities are provided in a distribution system to meet hourly fluctuations in water demand over the day, as discussed in Appendix F. If the source of supply is capable of supplying water at a rate equal to the maximum-day demands, then a volume equal to 15 - 20 percent of the maximum-day demand is usually sufficient to meet the hourly fluctuations in demand.

An alternative to supplying the above storage capacity is to provide additional supply capacity. In Bangued, additional supply capacity would mean providing more transmission main capacity from Lusuac Spring to Bangued. The rationale for providing additional supply, including a curve to estimate storage requirements at different rates of supply, is discussed in Methodology Memorandum No. 5.

Table VIII-3 shows the present worth analysis comparing the cost of additional supply (transmission capacity) with that of additional storage for Bangued. The comparison shows that it is more economical to provide additional storage capacity to a maximum of 15.5 percent of maximum-day demand and delay as long as possible construction of additional transmission mains.

Transmission System

The existing transmission system between Lusuac Spring and Bangued (see description in Chapter IV) is very old, and by 1984, would not have sufficient capacity to serve Bangued. The capacity of the 2 existing transmission mains is estimated to be 23.3 lps; however, with leakage due to deteriorated pipe conditions, the capacity would be much less. The following table shows the required capacity for 2 sections of the transmission main to carry maximum-day demands to Bangued.

Section 1 - Lusuac Spring to Peñarrubia (Length = 2,940 m)
1980 - 25.7 lps
1990 - 45.9
2000 - 78.1

Section 2 - Peñarrubia to Bangued (Length = 4,950 m)
1980 - 23.5 lps
1990 - 41.2
2000 - 69.6

TABLE VIII-3

PRESENT WORTH COSTS OF ALTERNATIVE STORAGE AND ADDITIONAL SUPPLY[7]

	Alternative 1 (Maximum Storage)	Alternative 2 (Intermediate Storage	Alternative 3 (Minimum Storage)
Storage Required (Percent)[8]	15.5	7.5	3.0
(Volume, cum)	1,010	490	200
Present Worth Cost (₱ x 1000)			
Storage[9]	₱ 150[10]	-	₱ -
Supply	3,070	4,600	5,270
Total	₱ 3,220	₱4,600	₱5,270

Section 1 of the transmission pipeline must be designed to carry the maximum-day demand of Bangued to the storage tank in Bangued, plus the peak-hour demands for Peñarrubia. Section 1 is designed to carry the peak-hour demands for the Peñarrubia area because there is no storage tank serving Peñarrubia. The flows to Peñarrubia are small so that providing the capacity within the transmission main does not affect its overall size. Therefore, there is no benefit derived from constructing a storage tank in Peñarrubia.

Section 2 from Peñarrubia to Bangued is designed to provide maximum-day demand while peak-hour demands are supplied to the distribution system from the existing storage tank.

The recommendations for transmission main improvements are included in Chapter IX. The estimated capacities for the transmission main are based on limited field data.

Alternative routes for the transmission main from Lusuac Spring to Bangued have been investigated during this study. No alternative routes offer any advantages over the existing route for Section 1 of the transmission main from Lusuac Spring to Peñarrubia. Future transmission main improvements between Lusuac Spring and Peñarrubia should be constructed parallel to the existing mains.

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[7] Analysis includes facilities required up to the year 2000.
[8] Percentage of maximum-day demand.
[9] Includes only storage in addition to existing 440-cum storage tank. It is assumed the existing tank would be adequate in Alternative 2.
[10] Based on constructing 2 additional tanks: 300 cum in 1985 and 270 cum in 1993.

An alternative to the existing route between Peñarrubia and Bangued has been considered. The proposed route would follow the National Road 306 from Peñarrubia to Bangued, passing through barrios Riang, Agtangao, Sao-atan and Lipoan. Although the alternative route is longer by about 2,260 meters, it could be used to serve areas that would require additional pipeline if the existing route is followed. Construction along the roadway would also be less expensive than across some of the wet areas the existing main passes through.

The 2 transmission main phases along the alternative route would have a diameter of 200 mm in 1980 and of 250 mm in 1986. Along the existing route, a 200 mm pipeline would be required in 1980 and an additional 200 mm pipeline in 1988. The difference in pipeline sizes and dates for construction is due to the longer pipeline requiring less headloss per meter to meet pressure requirements in the distribution system.

Table VIII-4 shows the difference in the present worth costs of the 2 alternative routes considered.

Besides the cost disadvantages of the alternative transmission main route along National Road 306, there are also certain hydraulic disadvantages. The static hydraulic gradeline along the alternate route would be high enough to require use of a higher class cast iron or asbestos cement pipe than would be required along the existing route. The high hydraulic gradeline would also require the use of pressure-reducing valves for each connection off the transmission main.

Based on the present worth cost analysis, it is more favorable to construct all additional transmission main capacity parallel to the existing mains than along National Road 306.

<u>Distribution System</u>

The analysis of the distribution system for Bangued generally conforms to the criteria set in Appendices F and K. In the First Ten-Area Feasibility Studies, the computer analyses were conducted only on pipelines larger than 200 mm, which were classified as distribution mains as differentiated from the internal network pipelines. In Bangued, there are no pipelines larger than 200 mm required through the year 2000; therefore, all pipelines within the poblacion and major pipelines to surrounding barrios have been included in the computer analysis.

The distribution analysis did not include different alternatives because the supply location and areas to be served were straightforward and there were no alternative methods of serving the area. An alternative analysis, however, was made in connection with fire protection.

TABLE VIII-4

PRESENT WORTH COST COMPARISON OF ALTERNATIVE TRANSMISSION MAIN ROUTES

Parallel to Existing Transmission Mains		Present Worth Cost
200-mm pipeline constructed in 1980		₱ 1,540,000
200-mm pipeline constructed in 1988		540,000
	Sub-total	₱ 2,080,000

Along National Road 306		
200-mm pipeline constructed in 1980		₱ 1,640,000
250-mm pipeline constructed in 1986		1,170,000
1980 distribution main not required[11]		-380,000
1990 distribution main not required[11]		- 60,000
2000 distribution main not required[11]		- 20,000
	Sub-total	₱ 2,350,000

Fire Protection

Fire protection does not exist in most sections of Bangued because there is little or no water pressure much of the day. To provide fire protection, there must be adequate pressure in all pipelines 24 hours a day.

In general, full fire protection to the entire municipality has not been provided in the immediate improvement program because of the high cost of full fire protection.

As outlined in Appendix K, there are 2 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 2 adjacent fire hydrants should be provided; and in the single-family residential areas, only 10 lps at 2 adjacent hydrants. Figure VIII-1 shows the outline of the fire service areas in Bangued.

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[11] These costs include those distribution mains that would not be constructed since the transmission main could provide service along its route.

In 1980, after the immediate improvement program has been completed, full fire protection can be provided along Taft Street since a new 150-mm pipeline would have been installed. Along streets more than a block or two from Taft Street, the available fire flow would only be about 50 percent of the required capacity. To obtain fire flow in 1980, the existing fire hydrants would have to be repaired.

By 1990, the existing mains within Bangued would nearly all be replaced with 100 mm and 150 mm pipelines so that the available fire flow would increase substantially. The available fire flow within the poblacion would equal the maximum requirements of the area. In this same year, 40 to 50 percent of the required fire flow would be available in the outlying barrios of Dangdangla, Patucannay, Calaba and Bangbangar if the pipelines to these areas are sized for 1990 peak-hour flows. Using the computer to select pipeline sizes serving the above barrios for the year 2000 peak-hour flow indicates that staging would not be recommended. If pipelines adequately sized for year 2000 peak-hour are constructed by 1990, the available fire flow in 1990 increases to between 75 and 90 percent of the required flow.

In order to provide the required fire flow to all areas, pipelines to barrios would have to be larger than that required for year 2000 peak-hour flow. Table VIII-5 indicates these additional pipeline costs directly attributed to providing full fire protection in the year 2000.

It is recommended that the pipeline constructed by 1990 be sized for the year 2000 peak-hour flow. Admittedly, the system would not be capable of providing full fire protection in 2000. However, it is difficult to predict the actual demands for the outlying barrios in 2000. Since adequate fire protection and adequate peak-hour service would be provided in 1990 and 2000, respectively, construction of the pipelines in 1990 to meet 2000 fire flows is not recommended in view of the cost.

System Operation

This section includes various operational aspects of the alternative distribution systems. Since there are no alternative distribution systems, no operation problems can be compared.

The BAN-WD would be a relatively simple system to operate. Water in the transmission main would flow by gravity, so there would be no pumping systems to control. The only control required in the system would be an altitude control valve located at the storage tank. This valve would automatically shut off flow in the transmission main when the storage tank is full. The BAN-WD would be operated directly from the tank.

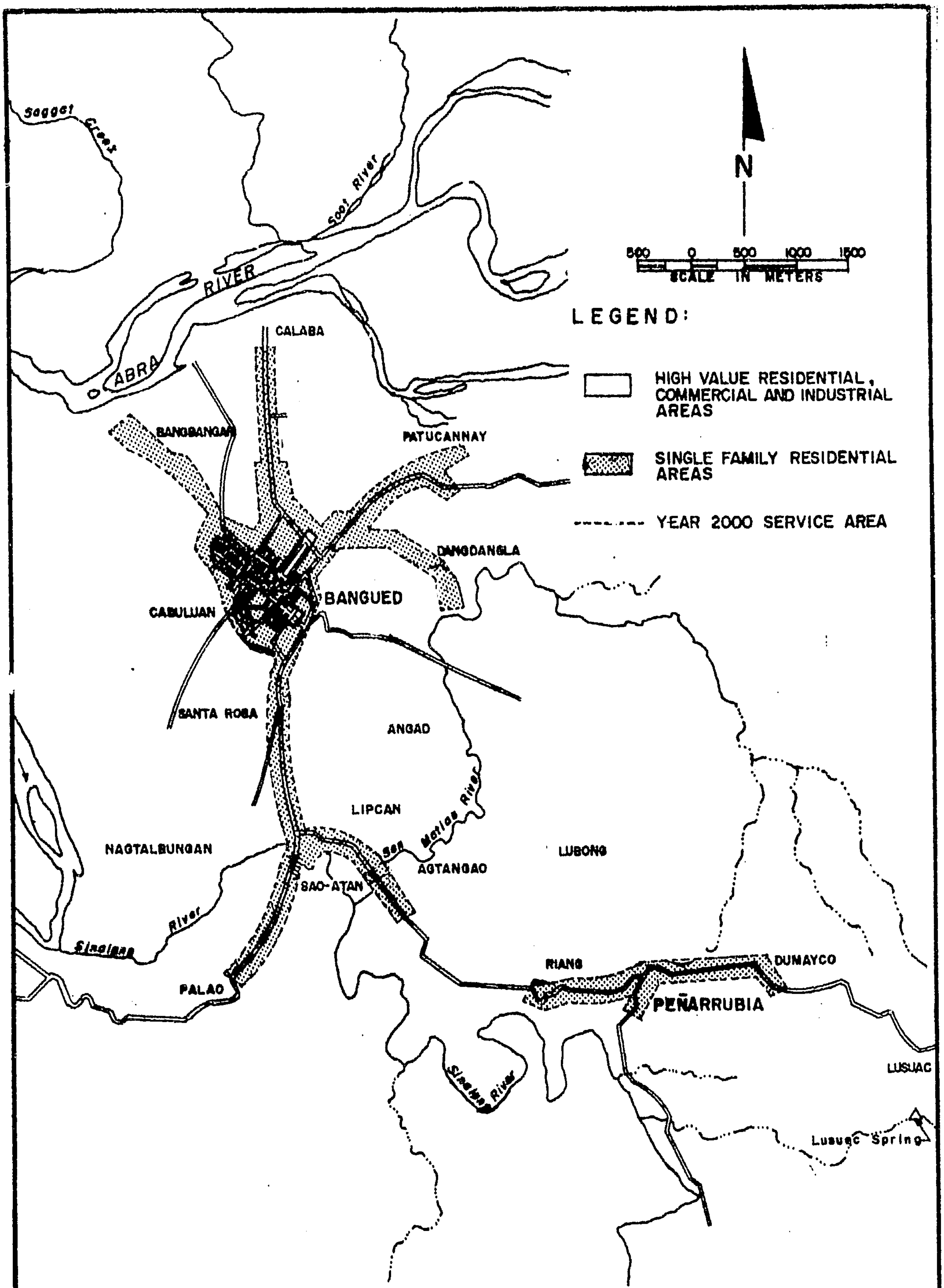


FIGURE VIII-1
FIRE PROTECTION AREAS
BANGUED WATER DISTRICT

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

TABLE VIII-5

ADDITIONAL PIPELINE COSTS TO PROVIDE
FULL FIRE PROTECTION IN 2000

Length (m)	Size for Partial Protection (mm)	Size for Full Protection (mm)	Additional Cost
1,840	100	150	₱ 160,000
1,775	150	200	150,000
Sub-total			265,000
Contingencies (15%)			40,000
			305,000
Engineering			30,000
			₱ 335,000

Internal Network

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

E. 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 wate. 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.

A N N E X   V I I I - B

SCHEDULE OF FACILITIES FOR ALTERNATIVE ANALYSIS

ANNEX VIII-B

SCHEDULE OF FACILITIES FOR ALTERNATIVE ANALYSIS

The costs for various supply alternatives are presented in Tables VIII-1 and VIII-2. These tables are a simplified summary of the costs included in the source analysis. A more detailed schedule of the anticipated facilities, costs and year constructed follows.

TABLE VIII-B-1

COMPARATIVE PRESENT WORTH COSTS OF ADDITIONAL SUPPLY ALTERNATIVES

Facility	Year Constructed	Construction Cost (P x 1000)	Present Worth Cost (Less Salvage Value) (P x 1000)
Induced Infiltration Wells on Abra River			
Source			
Test Wells	1980	73	58
Well and Dual Drive Pumphouse	1984	396	198
Power Lines	1984	100	47
Well and Pumphouse	1985	265	111
Collection Pipe	1985	90	36
Well and Pumphouse	1992	265	39
Collection Pipe	1992	125	17
Well and Pumphouse	1998	265	7
Collection Pipe	1998	125	3
Replace Drive	1998	90	3
	Sub-total	1,794	519
Transmission Mains			
	1984	750	338
	1998	1,000	24
	Sub-total	1,750	362
Distribution Mains	1984	150	68
	1992	150	20
	Sub-total	300	88
Operation and Maintenance	1983-2000	-	281
	Total	3,844	1,250

TABLE VIII-B-1 (Continued)

Facility	Year Constructed	Construction Cost (₱ x 1000)	Present Worth Cost (Less Salvage Value) (₱ x 1000)
Wells in Service Area			
Source			
Test Wells	1980	213	170
Well and Pumphouse	1984	269	128
Well and Pumphouse	1985	269	113
Well and Dual Drive Pumphouse	1989	345	87
Well and Pumphouse	1992	269	40
Well and Dual Drive Pumphouse	1994	345	37
Well and Pumphouse	1996	269	16
Well and Pumphouse	1998	269	7
	Sub-total	2,248	598
Transmission Mains			
	-	-	-
Distribution Mains			
	-	-	-
Operation and Maintenance			
	1983-2000	-	235
	Total	2,248	833
Lusuac Spring			
Source			
	-	-	-
Transmission Mains			
	1984	1,475	664
	1993	1,475	165
	Sub-total	2,950	829
Distribution Mains	1984	150	68
	1993	150	17
	Sub-total	300	85
Operation and Maintenance			
	1983-2000	-	47
	Total	3,250	961

TABLE VIII-B-2

COMPARATIVE PRESENT WORTH COSTS OF ADDITIONAL SUPPLY ALTERNATIVES
(Assuming One Transmission Main Is Abandoned by 1984)

Facility	Year Constructed	Construction Cost (P x 1000)	Present Worth Cost (less Salvage Value) (P x 1000)
Wells in Service Area			
Source			
Test Wells	1980	213	170
Three Wells and Pumphouses	1984	807	385
Well and Dual Drive Pumphouse	1985	345	150
Well and Pumphouse	1988	269	75
Well and Pumphouse	1990	269	56
Well and Pumphouse	1993	269	33
Well and Dual Drive Pumphouse	1995	345	29
Well and Pump	1997	269	12
Well and Pumphouse	1999	269	4
	Sub-total	3,055	914
Transmission Mains	-	-	-
Distribution Mains	-	-	-
Operation and Maintenance	1983-2000	-	538
	Total	3,055	1,452
Lusuac Spring			
Source	-	-	-
Transmission Main	1984	1,992	897
	1993	1,473	148
	Sub-Total	3,465	1,045
Distribution Mains	1984	150	68
	1993	150	15
	Sub-total	300	83
Operation and Maintenance	1983-2000	-	40
	Total	3,765	1,168

CHAPTER IX DESCRIPTION AND COST OF THE RECOMMENDED PLAN

A. GENERAL

This chapter describes the immediate improvement program, and the first and second stages of the long-term construction program. In addition, the capital and operation and maintenance costs of the recommended program, concepts concerning sewerage and drainage, comments regarding the management of water resources and a statement regarding the environmental impact of this project are included. Appendices F, G, N and O, Volume II contain discussions of Design Criteria, Basis of Cost Estimates, Construction Methods and Materials, and Outline Specifications, respectively. The recommended construction program consists of the following 5 implementation steps:

1. Immediate Improvement Program (1978-79)
2. Stage I Phase A of the Long-Term Construction Program (1980-85)
3. Stage I Phase B of the Long-Term Construction Program (1986-90)
4. Stage II Phase A of the Long-Term Construction Program (1991-95)
5. Stage II Phase B of the Long-Term Construction Program (1996-2000)

Source

The current source of water supply to Bangued, Lusuac Spring, is located approximately 8.0 km southeast of the municipality and serves the community via two existing 150 mm parallel pipelines. The capacity of the spring is about 18,000 cumd. The spring will be utilized as a water supply source for the water district and will be adequate to provide projected maximum-day demand well past the year 2000, at which time maximum-day demand is expected to be about 6,500 cumd. The existing collection facilities are currently adequate, but will be augmented during construction Phase I-A, after which additional expansion will not be required within the design period of this project.

The BAN-WD will also be required to file an application with the National Water Resources Council to secure water rights on Lusuac Spring.

Storage

Bangued currently has 440 cum of distribution storage located on a hill about ½ km southeast of the poblacion. The existing tank is a concrete ground level storage tank constructed in 1919.

The discussion of storage facilities in Chapter VIII indicates that the BAN-WD should maintain as close to 15 percent of maximum-day demand as possible, for storage to the year 2000. Based on the expected capacity and staging of the transmission system from Lusuac Spring to Bangued, only about 10 percent of the maximum-day demand or 640 cum would actually be necessary to meet peak-hour fluctuations in the year 2000. It is recommended to construct an additional 200 cum ground level storage tank by 1993 at the same location as the existing tank.

Transmission System

The existing transmission system will be thoroughly tested by 1980 to determine what portions can continue to serve Bangued. It is estimated that regardless of the results of tests on the existing transmission mains, an additional 200-mm transmission main will be constructed along the existing transmission main route during Phase I-A. A second parallel 200-mm transmission main will not be necessary until Phase II-B as long as adequate storage is provided during Phase II-A and the water demands do not exceed the current estimates. Delaying construction of the second transmission main to Phase II-B is more probable if one of the existing transmission mains can be maintained in service up to 1995. After 1995 it is assumed that both of the existing transmission mains will be abandoned.

Distribution System

The existing distribution system of BAN-WD serves the poblaciones of Bangued and Peñarrubia and the barrios of Lipcan and Dumayco, and was constructed in about 1919. The existing system will be expanded to serve the barrio of Dangdangla in 1980 and the barrios of Bangbangar, Calaba, Patucannay and Riang by the year 1990 and serve Agtañgao, Palao and Sao-atan by the year 2000.

A total of about 18 km of 100 mm, 150 mm and 200 mm pipeline will be constructed by 1990, including 15 km of pipeline to replace those pipelines in the existing system that are undersized and are in poor condition. An additional 10 km of 100, 150 mm and 200 mm pipeline will be constructed by the year 2000. The above lengths of pipelines do not include new internal network pipelines that will be constructed in the newly served areas.

Figure IX-1 (appended) shows the overall recommended program of construction by phases.

Administrative and Other Service Facilities

In addition to the source transmission and distribution facilities required for the production and transportation of water to consumers, it will be necessary to provide other facilities to improve administrative, operation, maintenance and quality control capabilities within the water district. An administration building will be constructed during the immediate improvement program and will temporarily house plumbing shop facilities. A plumbing shop, meter repair shop and laboratory will be constructed in Phase I-A.

B. IMMEDIATE IMPROVEMENT PROGRAM

While the findings and recommendations of this report are being reviewed, pending their approval by the BAN-WD, LWUA and financial agencies, certain steps may be taken to facilitate immediate improvements in the BAN-WD water supply system. These "high-impact" improvements will provide improved service to existing consumers and provide additional service to a limited number of new connections to the system, before implementation of the long-term construction program.

The existing source and transmission facilities (except for the addition of a short length of pipeline immediately upstream of the existing reservoir) are considered adequate for the projected water requirements of the BAN-WD beyond the year 1980. The present supply to the existing service area is over 2,200 cumd, providing 330 lpcd to an estimated 6,720 existing consumers.

The immediate improvement program will increase water supply service primarily by the addition of distribution facilities. The program consists of the following:

1. The installation of about 6.1 km of 100 to 250 mm diameter pipelines.
2. The initiation of an extensive leakage detection survey and repair program.
3. The addition of reliable disinfection equipment to provide full-time chlorination of the distribution system.
4. The metering of 868 existing service connections as well as the provision of 494 new connections and repair of about 30 percent of the existing connections.
5. The construction of new administrative building (temporarily housing the plumbing shop) and the provision of appurtenances such as shop tools, vehicle, office equipment and furniture, etc. to upgrade the water district's operational capabilities.
6. Repair of leaks in existing storage tank.

New distribution mains will be installed as shown in Figure IX-2 and summarized below:

Location	Diameter (mm)	Length (m)
Agoncillo Street	100	100
Taft Street	100	180
Washington Street	100	110
Purugganan Street	100	270

Manzano Street	100	190
Partelo Street	100	150
Bo. Dangdangla Road	100	1,040
Peñarrubia*	100	830
Sub-total		2,870
Peñarrubia*	150	250
Taft Street	150	170
Economia Street	150	775
Sub-total		1,195
Taft Street	200	520
Torrijos Road	200	860
Sub-total		1,380
From Reservoir to Torrijos Road	250	295
To Reservoir from Source	250	365
Sub-total		660
Total		6,105

*In Poblacion of Peñarrubia, not shown on Figure IX-2.

The provision of 200 mm pipes along Torrijos Road and Taft Street will not only provide more capacity for additional service connections but will also serve as segments of anticipated future water mains. The pipeline along Taft Street will immediately provide better water pressure to the northwestern section of the system. The construction of additional 100 mm mains will permit the connection of additional consumers and will provide additional loops for better pressure and flow distribution. One thousand eighty (1,080) meters of 100 and 150 mm pipe will be installed in Peñarrubia municipality where the current supply is via 25-mm piping.

The provision of better pressure throughout the BAN-WD distribution system on a 24-hour basis will tend to aggravate the current level of system leakage and wastage. It is, therefore, essential that an intensive program of leakage and wastage surveys and associated system repairs be undertaken during the immediate improvement program.

Chlorination equipment, complete with a separate structure, will be provided at the site of the existing Lusuac Spring intake facilities to provide an initial dosage of 2.0 mg/l to maintain a minimum chlorine residual of 0.1 mg/l at all points within the distribution system. In order that the existing collection chamber may be used for chlorination of all water flowing from the source, the existing 150-mm pipeline currently by-passing the chamber should be reconnected through the chamber.

A check valve will also be installed between the existing intake box and the pool to reduce possible risks of contamination in the transmission system.

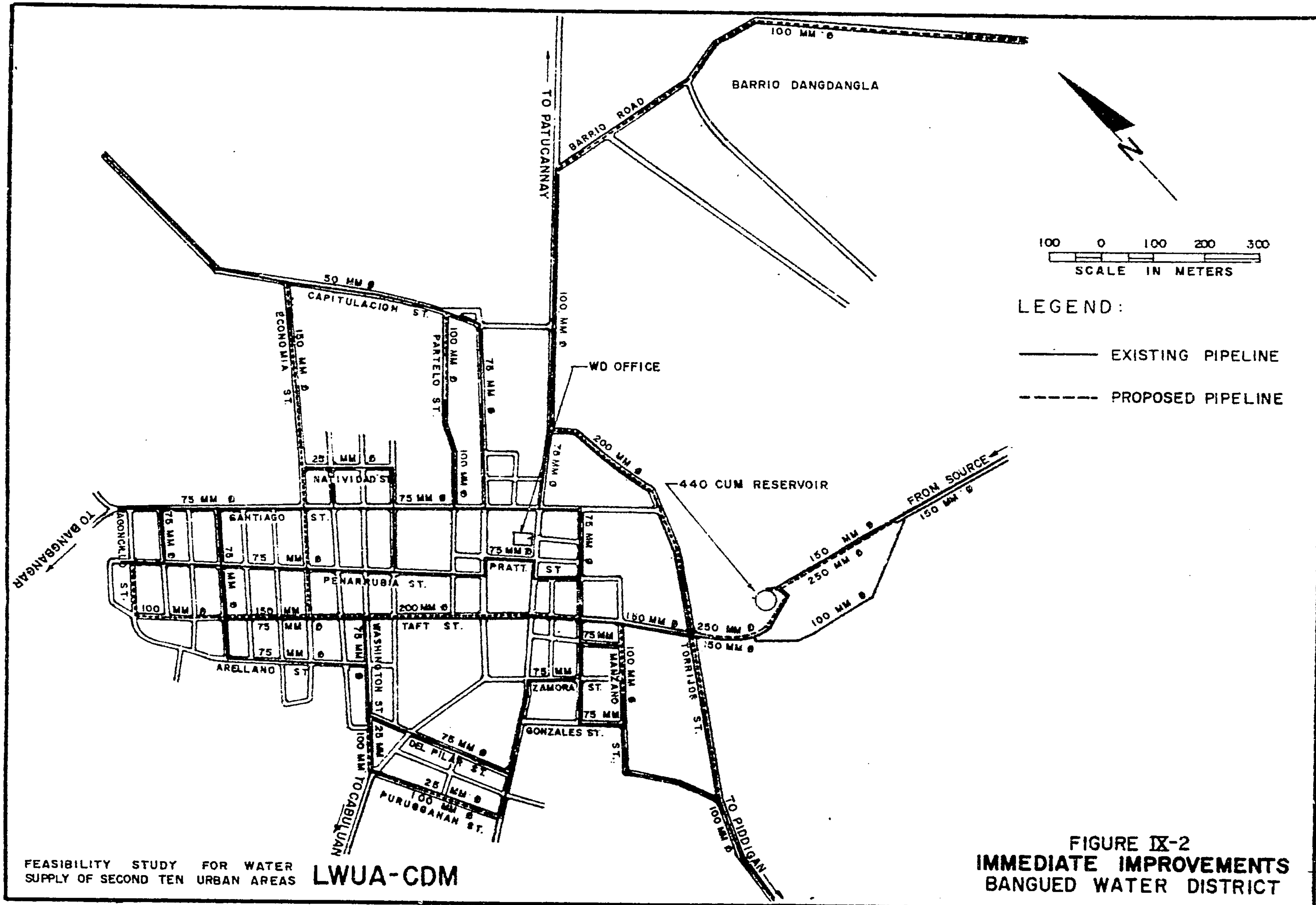


FIGURE IX-2
IMMEDIATE IMPROVEMENTS
BANGUED WATER DISTRICT

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

The existing flat-rate service connections will be provided with water meters; about 30 percent (260) of these connections will be repaired or replaced. Some 494 new connections will be added, increasing the 1980 served population to 70 percent of the total population within the service area.

The operational capabilities of the BAN-WD will be significantly enhanced by the acquisition of land and the construction of a new 300 sqm administrative building, complete with office space for administration, billing and record keeping, as well as a small library. This new building will be furnished with desks, filing cabinets, typewriters, addressograph and validating machines. Plumbing equipment will be purchased and a portion of the administration building will be used as a plumbing shop until permanent plumbing shop facilities are provided during Phase I-A.

Table IX-1 presents the breakdown of costs (at July 1978 price levels) for the immediate improvement program. The total project cost of ₱3.51 million consists of ₱1.74 million in foreign exchange and ₱1.77 million in local currency.

C. FIRST STAGE OF THE LONG-TERM CONSTRUCTION PROGRAM

As a result of alternative studies (Chapter VIII), the recommended scheme for the construction of source and transmission facilities has been selected. The Lusuac Spring will continue to serve the BAN-WD service area up to 2000. New transmission facilities will be constructed along the alignment of the existing transmission pipelines.

The first stage of the recommended constructiom program, including source development, treatment, transmission and distribution facilities, will be implemented in 2 construction phases with duration of 6 years and 5 years, respectively.

Existing facilities are incorporated into the recommended scheme to the maximum extent practical. The older of the two existing 150 mm transmission pipelines may be abandoned during the early part of the first construction stage after a detailed hydraulic study is performed. However, the second existing transmission pipeline will be retained until the second stage. Similarly, existing distribution pipelines will be replaced during the decade 1980-1990, half to be replaced during the first half of the decade, the remainder to be replaced during the later half.

TABLE IX-1

COST SUMMARY
IMMEDIATE IMPROVEMENT PROGRAM[1]

Item	Cost in Pesos Local	Foreign[2]	Total	Remarks
Distribution Facilities				
1. Leakage Detection and Repair				
Materials and Equipment	5,000	8,000	13,000	Specialist fees, travel and equipment; miscellaneous valve repair and replacement.
Civil and Structural	18,000	86,000	104,000	
2. Distribution System Pipelines				
Materials and Equipment	144,400	621,000	765,400	Construct 2,870 meters of 100mm, 1,195 meters of 150mm, 1,380 meters of 200mm and 660 meters of 250mm pipeline.
Civil and Structural	475,600	-	475,600	
3. Disinfection Facilities				
Materials and Equipment	1,700	20,600	22,300	Construct a 3 m x 3 m structure and install chlorinator, booster pump scales and accessories.
Civil and Structural	9,100	900	10,000	
	653,800	736,500	1,390,300	
Storage Facilities				
4. Existing Storage Tank				
Materials and Equipment	-	16,000	16,000	Repair cracks in floor.
Civil and Structural	12,500	-	12,500	
	12,500	16,000	28,500	
Service Connections				
5. Installation, Conversion and Repair of Service Connections				
Materials and Equipment	17,900	480,400	498,300	Convert 878 connections to metered, replace 263 existing connections and install 494 new connections.
Civil and Structural	266,000	-	266,000	
	283,900	480,400	764,300	

1/ Based on July 1978 prices.

2/ Based on an exchange rate of US$1.00 to ₱7.00.

TABLE IX-1 (Continued)

Item	Cost in Pesos Local	Foreign	Total	Remarks
Administrative and Miscellaneous Facilities				
6. Administrative Building and Equipment				
Materials and Equipment	20,000	69,000	89,000	Provide 300 sqm of floor space, typewriters (3), addressograph (1), validator (1), calculators (2), filing cabinets (7), desks (10), chairs (20) and plumbing tools. Land cost included as a separate item.
Civil and Structural	363,000	-	363,000	
7. Vehicles				
Materials and Equipment	30,000	30,000	60,000	Purchase one van or pick-up type vehicle.
Civil and Structural	-	-	-	
8. Miscellaneous Items				
Materials and Equipment	5,000	8,000	13,000	Purchase chlorine residual analyzers, minor distribution system repair items and miscellaneous publications.
Civil and Structural	-	-	-	
	418,000	107,000	525,000	
Total Construction Cost				
Materials and Equipment	224,000	1,253,000	1,477,000	
Civil and Structural	1,144,200	86,900	1,231,100	
Total	1,368,200	1,339,900	2,708,100	
Contingencies @ 15%	205,200	201,000	406,200	
Sub-total	1,573,400	1,540,900	3,114,300	
Engineering @ 10% [3]	109,000	202,400	311,400	
Sub-total	1,682,400	1,743,300	3,425,700	
Land Costs	84,000	-	84,000	
TOTAL PROJECT COST	1,766,400	1,743,300	3,509,700	

[3] Consists of 65 percent foreign exchange and 35 percent local currency based on recent consulting projects.

CONSTRUCTION PHASE I-A (1980-85)

Source Development

The present supply of water to BAN-WD comes from Lusuac Spring. The existing collection facilities consist of a rock retaining embankment, a concrete collection chamber and the associated connection piping. Water flows by gravity via two possible routes into the existing 150 mm transmission pipes. The first route consists simply of 150 mm pipe which passes directly through the rock embankment and transmits water directly into one of the two transmission pipes. The second route involves a piping system (a single 200 mm pipe and three 75 mm pipes, all in parallel) connecting the spring pool and the concrete collection chamber, from which water is transmitted to the second 150 mm transmission pipe.

During Phase I-A the spring collection facilities will be improved and expanded to provide source capacity for the BAN-WD up to the year 2000 (see Figure IX-3). These improvements and additions will include the following:

1. Construction of a reinforced-concrete cut-off wall along northern, southern and western sides of the existing spring pool. This will eliminate the large leaks which currently occur in the rock embankment.

2. Construction of a fence along the top of the proposed cut-off wall and around the remainder of the immediate spring area.

3. Construction of a new reinforced concrete collection chamber to accommodate expected year 2000 flows. The preliminary design of this facility includes provision for a broad-crested weir within the structure for source flow measurement.

4. Provision and installation of required appurtenant piping and valves. The preliminary design includes two 250 mm x 10 m inlets pipes, two 250 mm x 10 m outlet pipes and a single 150 mm x 20 m drain pipe.

5. Construction of a drainage channel to conduct surface water drainage from the area north of the existing spring pool to the existing spring overflow stream west of the spring area.

6. Construction of a metering/valve chamber along the transmission pipeline route on the upstream side of the municipality of Peñarrubia. This facility will include primary source flow metering devices and pressure-reducing valves

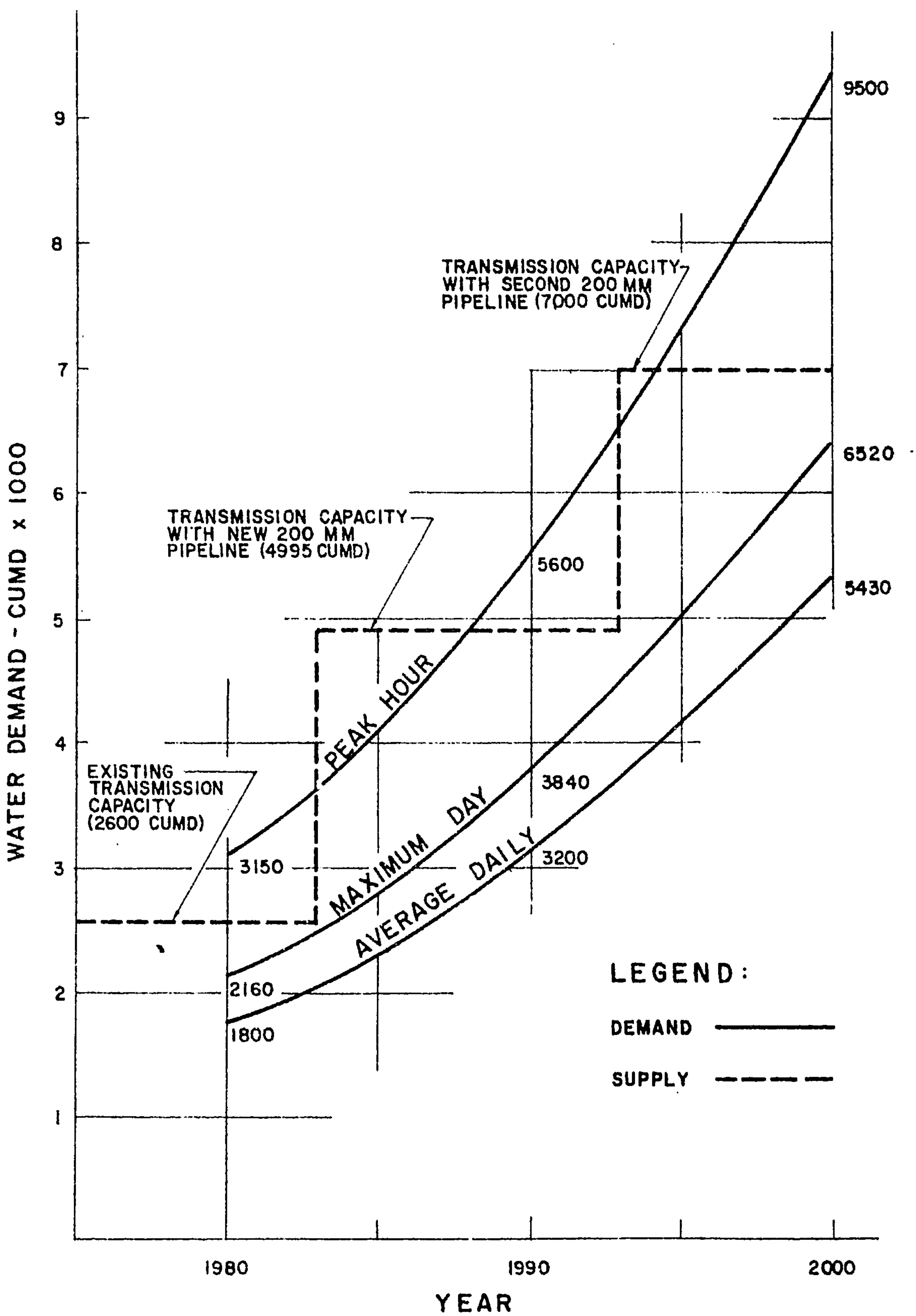


FIGURE IX- 3
PROJECTED
WATER DEMAND AND SUPPLY
BANGUED WATER DISTRICT

required for service to Peñarrubia. All required valves and piping for this equipment have been included in the preliminary design of this facility.

Figure IX-4 shows a schematic plan of these proposed facilities (excluding the meter/valve chamber).

Transmission Facilities

The two existing 150 mm transmission pipelines will continue to provide service to the BAN-WD service area until 1984. During Phase I-A, the older of the two pipelines (constructed in 1919) will be abandoned and replaced by a proposed 7,890 m x 200 mm pipeline, extending from the Lusuac Spring collection facilities to the existing 440 cum storage reservoir along the existing right-of-way. The resulting parallel system of existing 150 mm and proposed 200 mm pipelines will have sufficient capacity to provide service to the BAN-WD until approximately 1996. The parallel system would only be adequate to 1996 if the existing 150 mm pipeline is maintained in service. The proposed 200 mm pipeline alone has adequate capacity for only 1990 flows. After 1990, a second parallel 200 mm transmission main would need to be constructed as soon as the existing 150 mm main is removed from service.

All appurtenant gate valves, specials and vacuum/air relief valves have been included in the cost estimates. The hydraulic grade line of the proposed transmission pipeline, under expected 1990 maximum-day flow conditions, is shown in Figure IX-5. The general layout of proposed transmission facilities is shown in Figures IX-6 and IX-1 (appended).

Distribution System

The distribution system improvements included in construction Phase I-A will replace a portion of existing pipelines and serve the barrios of Patucannay, Calaba, Bangbangar and Riang. Figures IX-6, IX-7 and IX-1 (appended) and Table IX-2 show the pipelines to be constructed during Phase I-A. The replacement pipelines are sized in accordance with the recommended internal network sizing since the system within the poblacion is essentially internal network. Pipelines to serve the 4 additional barrios are sized for peak-hour flows expected in the year 2000. It is not cost-effective to stage those pipelines if the required size for the design period is 150 mm.

The final computer printout for the year 2000 peak-hour flow is included in Annex IX-C.

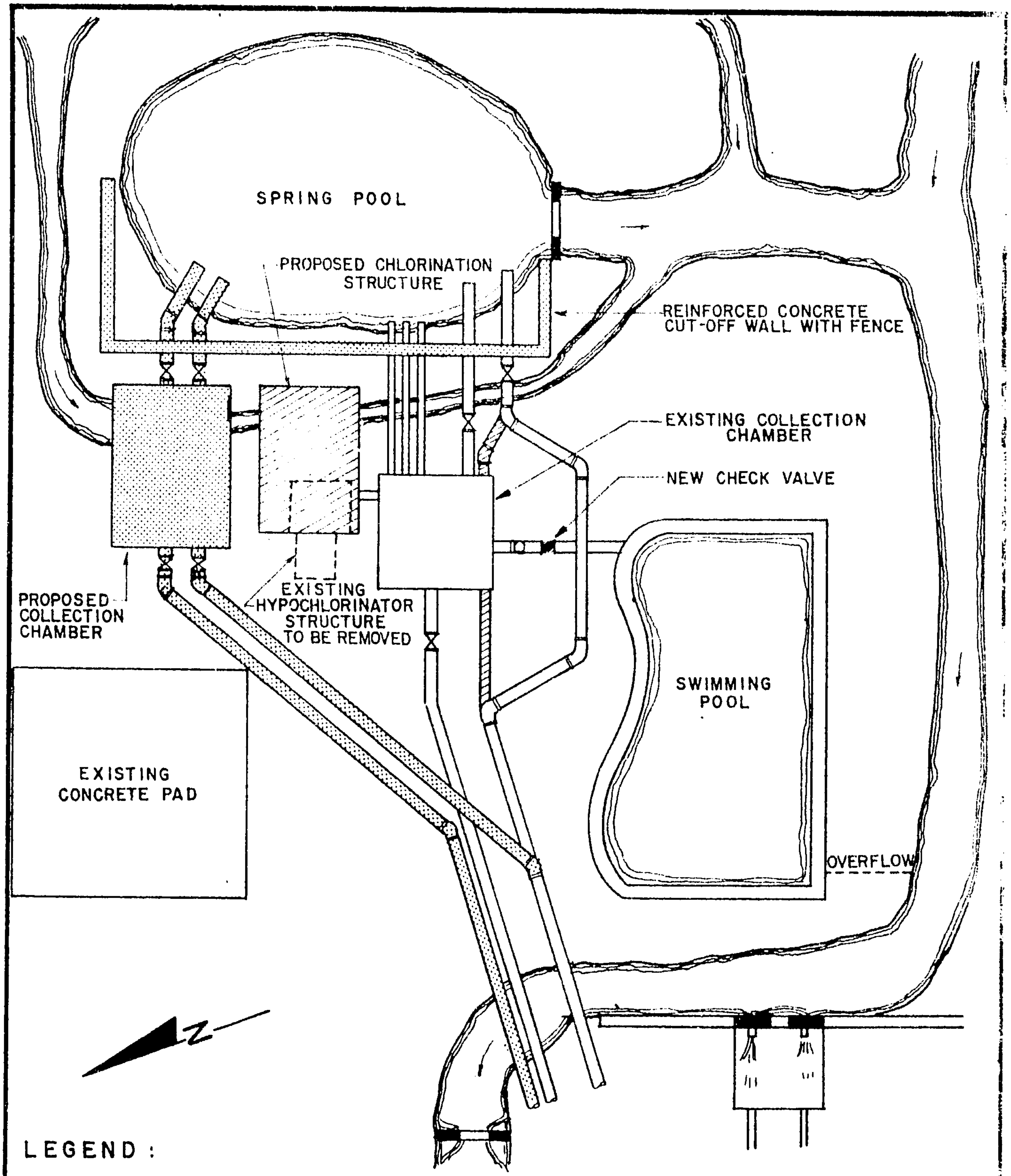
TABLE IX-2

PHASE I-A TRANSMISSION AND DISTRIBUTION PIPELINES

Pipe Number	Location/Description	Pipe Diameter (mm)	Pipe Length (m)
32	Capitulacion St.	100	65
33	Capitulacion St.	100	310
			375
5	Aguinaldo St.	150	100
9	Bowen St.	150	230
19	Rizal St.	150	90
20	Rizal St.	150	180
21	Zamora St.	150	105
34	Abra-Ilocos Norte Nat'l. Road	150	640
201	Bo. Patucannay Road	150	1,250
202	Bo. Calaba Road	150	1,000
203	Bo. Bangbangar Road	150	1,300
204	Bo. Riang Road	150	1,100
			5,995
22	Magallanes St.	200	40
23	Magallanes St.	200	70
25	Taft St.	200	75
40	Taft St.	200	130
49	Transmission Pipeline to Reservoir	200	4,950
51	Transmission Pipeline to Reservoir	200	2,940
			8,205
		TOTAL	14,575

Internal Network

The schedule of additions to the internal network system is presented in detail in Annex IX-C. The existing internal network system in Bangued will be improved by replacing the old 100 mm, 75 mm and smaller pipes, installing new valves, and serving areas which are currently unserved.



LEGEND:

IMMEDIATE IMPROVEMENTS

PHASE I-A IMPROVEMENTS

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

FIGURE IX-4
PROPOSED SOURCE FACILITIES
SCHEMATIC
BANGUED WATER DISTRICT

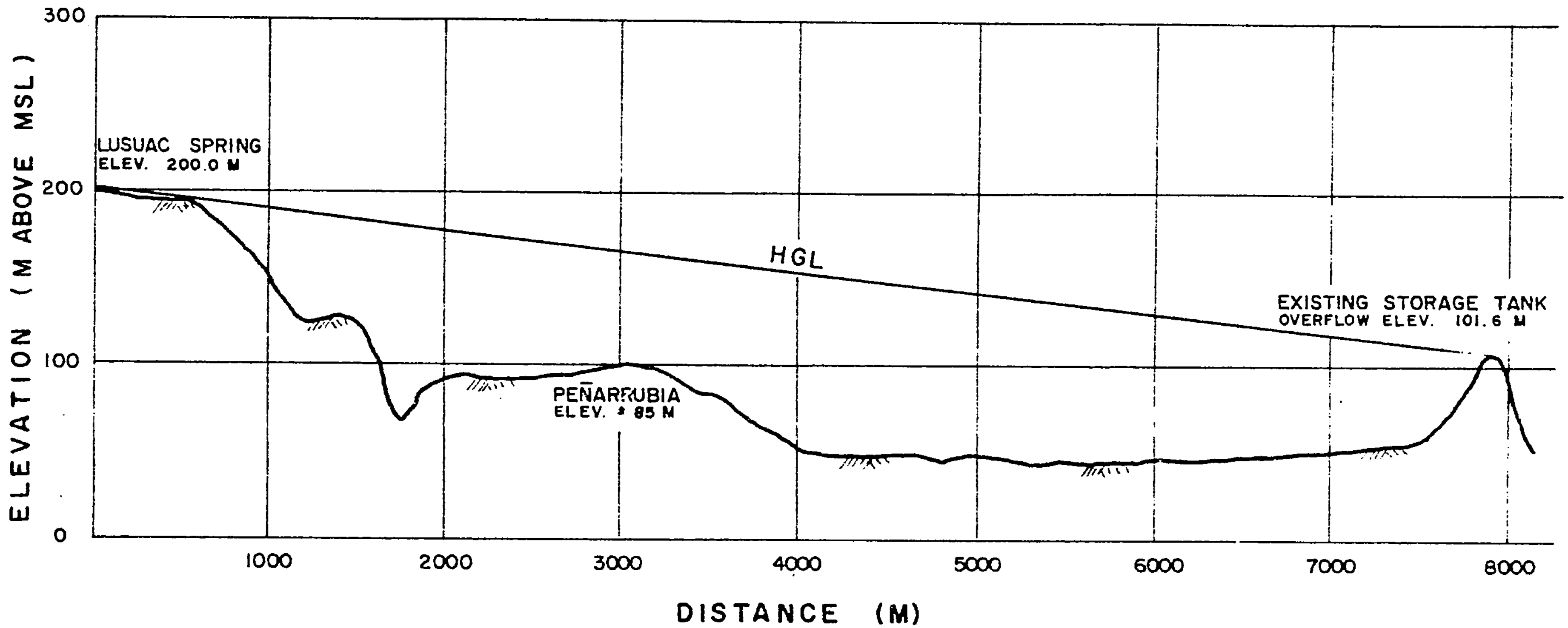


FIGURE IX-5
HYDRAULIC GRADELINE
FOR TRANSMISSION SYSTEM -1990
BANGUED WATER DISTRICT

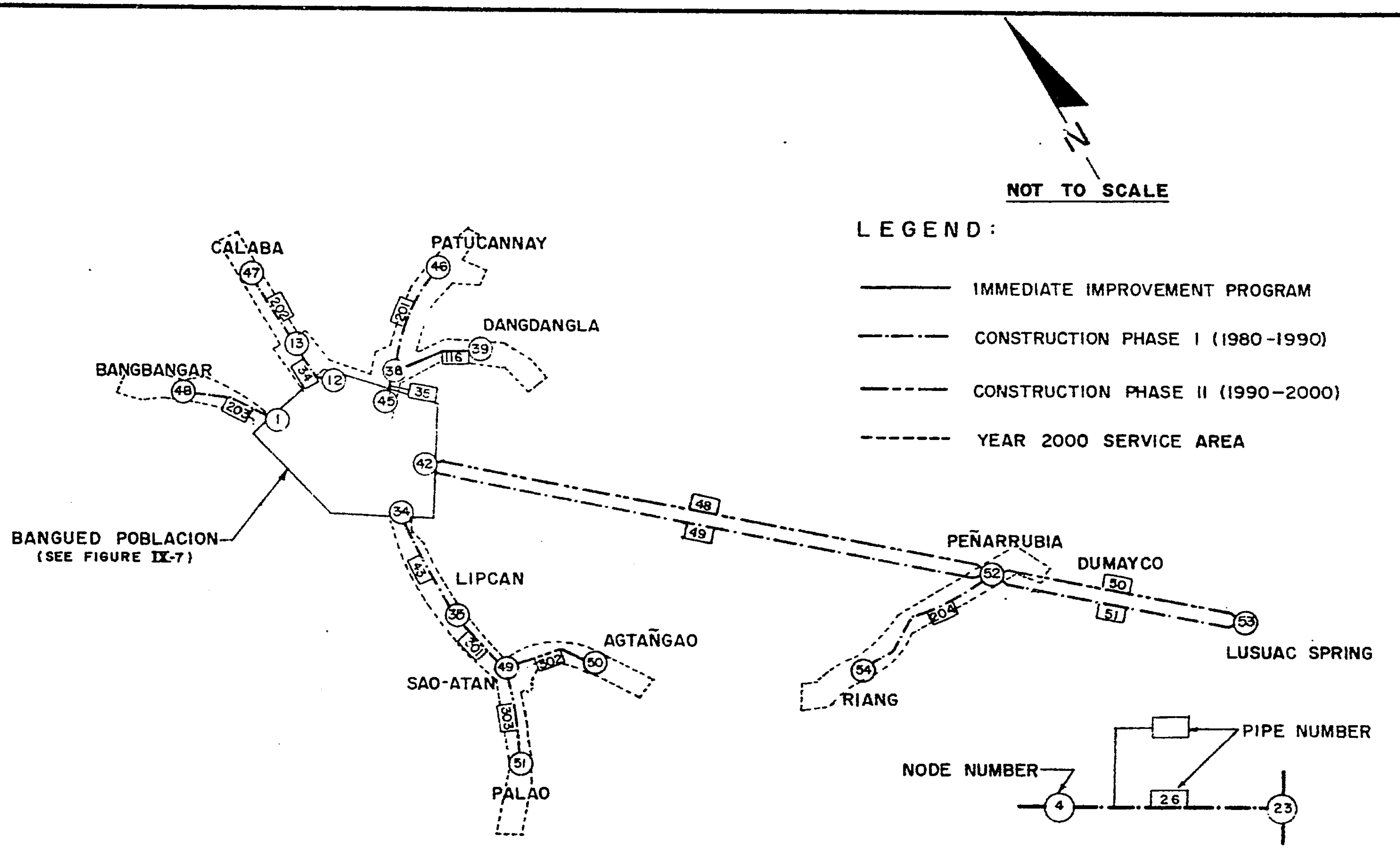


FIGURE IX-6
SCHEMATIC PLAN OF DISTRIBUTION SYSTEM
BANGUED WATER DISTRICT

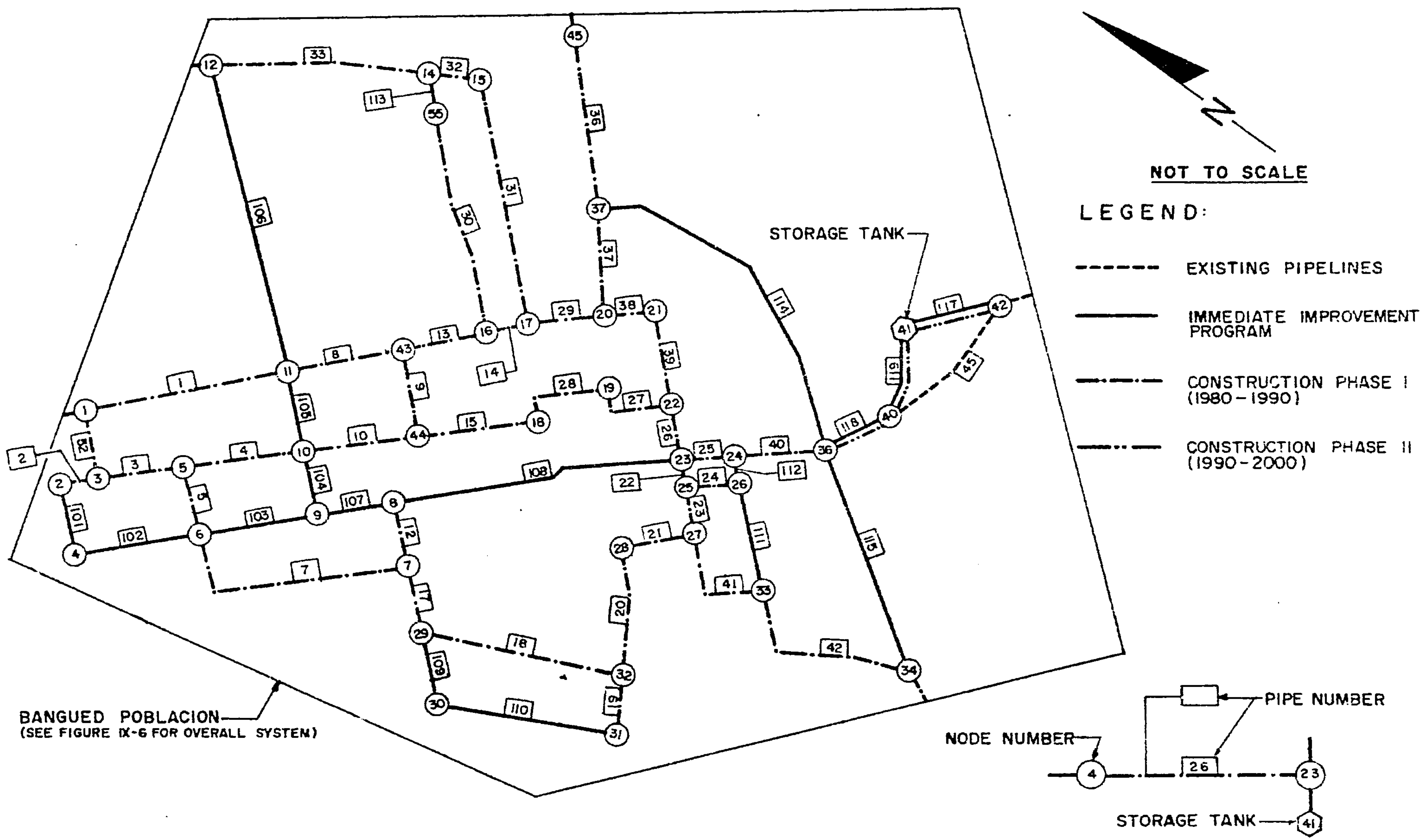


FIGURE IX-7
SCHEMATIC PLAN OF DISTRIBUTION SYSTEM
(POBLACION)
BANGUED WATER DISTRICT

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

The total area served by additional internal network is about 88 hectares. This will provide service to 100 percent of the 1976 service area, 100 percent of the additional area to be served by 1980 and 55 percent of the additional area to be served by 1990. Areas adjacent to distribution system pipelines will receive service directly from these pipelines and have been deducted from the total internal network requirement. A description of internal network systems is presented in Appendix K, Volume II.

Service Connections

During Phase I-A, a total of 605 new service connections will be installed, at a rate of about 120 connections per year, increasing the number of service connections to 1,970 within the water district by 1985. The schedule of service connection installations is presented in Annex IX-C.

Fire Protection

The schedule for fire hydrant installation within the water district is presented in Annex IX-C. By 1985, a total of 69 hectares will be provided with fire protection service by the installation of fire hydrants. This area includes 41 hectares of Bangued Poblacion, 5 hectares of Peñarrubia Poblacion, and 23 hectares within the surrounding barrios. Bangued Poblacion will receive a higher standard of service because of its high population density and high-value property.

Laboratory Facilities

In order to monitor and maintain water quality control of the water provided by BAN-WD to its consumers, a 70 sqm laboratory will be constructed during Phase I-A. It will have general laboratory equipment and specialized equipment for routine water chemical analyses and bacteriological analyses. All required furniture and fixtures will be provided. The laboratory facilities provided during Phase I-A will be adequate beyond the period of the first construction stage and will be increased in 1994-95 (Phase II-A).

Plumbing Shop Facilities

Because of expanding water district staff and water supply facilities, it is anticipated that the administrative building (housing both administrative staff and plumbing facilities) will become overcrowded during the early part of construction Phase I-A. Therefore, a separate 370 sqm plumbing shop will be constructed during this phase. Provision of this facility will permit expansion of maintenance and plumbing capabilities within the water district.

Water Meter Test/Repair Facilities

The provision of water meters is a critical factor in increasing the overall accounted-for-water within a water supply system. For this reason, facilities for the testing and repair of meters will be provided during Phase I-A. These facilities will include space in the plumbing shop (70 sqm), test benches, test tanks, repair benches and required furniture and tools. It is anticipated that the facilities provided during this construction phase will be adequate until 1991-92 (Phase II-A), at which time some additional equipment will be required.

Cost Summary - Phase I-A

The cost summary for proposed construction during Phase I-A is presented in Table IX-3. Based on 1978 price levels, the total project cost for this phase is ₱7.25 million with a foreign exchange component (FEC) of ₱3.58 million which includes direct and indirect import items. Table IX-3 also shows a cost breakdown based on materials and equipment procurement and required civil and structural work. Materials and equipment considered in this breakdown include pipes, valves, water meters, hydrants and chlorinators.

CONSTRUCTION PHASE I-B (1986-90)

Distribution System

All of the distribution system improvements included in construction Phase I-B are to replace existing pipelines (constructed before 1978) in the BAN-WD. Figures IX-6, IX-7 and IX-1 (appended) and Table IX-4 show the pipelines to be constructed during Phase I-B.

The sizes of replacement pipelines are selected in accordance with the recommended internal network scheme since the system within the poblacion is essentially all internal network.

Internal Network

New internal network (54 hectares) will be provided during this construction phase to provide 100 percent coverage of the 1990 service area. Internal network will be provided at an annual rate of approximity 10.8 hectares per year, uniformly over the period 1986-90 (see Annex IX-C).

Service Connectionss

During Phase I-B a total of 606 new service connections will be installed, at a rate of approximately 120 connections per year, increasing the total service connections to 2,570 within the water district by 1990 (See Annex IX-C).

TABLE IX-3

COST SUMMARY FOR CONSTRUCTION
STAGE I PHASE A (1980-85)

Item	Construction Period	Cost (₱) Local	FEC[4]	Total
Source Development	1981-82			
Materials and Equipment		6,300	116,000	
Civil and Structural		81,300	-	
		87,600	116,000	203,600
Pipelines and Valves	1981-82			
(100 mm x 375 m)				
Materials and Equipment		2,800	17,800	
Civil and Structural		20,900	-	
(150 mm x 5,995 m)				
Materials and Equipment		144,100	562,800	
Civil and Structural		461,100	-	
(200 mm x 8,205 m)				
Materials and Equipment		259,300	1,017,500	
Civil and Structural		678,100	-	
		1,566,300	1,598,100	3,164,400
Laboratory Facilities	1981-82			
Materials and Equipment		21,400	224,000	
Civil and Structural		118,500	50,000	
		139,900	274,000	413,900
Meter Repair Facilities	1981-82			
Materials and Equipment		4,400	55,600	
Civil and Structural		55,000	-	
		59,400	55,600	115,000
Plumbing Shop	1981-82			
Materials and Equipment		-	-	
Civil and Structural		363,000	-	
		363,000	-	363,000
Sub-Total[5]				
Materials and Equipment		438,300	1,993,700	2,432,000
Civil and Structural		1,777,900	50,000	1,827,900
		2,216,200	2,043,700	4,259,900
Internal Network	1981-85			
Materials and Equipment		47,300	370,400	
Civil and Structural		467,700	-	
		515,000	370,400	885,400

4/ U.S. $1.00 = ₱7.00.

5/ Contingencies and engineering calculated at 15 and 10 percent, respectively. Engineering costs include 65 percent foreign exchange.

TABLE IX-3 (Continued)

Item	Construction Period	Cost (₱) Local	FEC	Total
Service Connections	1981-85			
Materials and Equipment		14,500	293,300	
Civil and Structural		198,200	-	
		212,700	293,300	506,000
Fire Hydrants	1981-85			
Materials and Equipment		23,700	80,900	
Civil and Structural		34,900	-	
		58,600	80,900	139,500
Vehicle	1981			
Materials and Equipment		30,000	30,000	
Civil and Structural		-	-	
		30,000	30,000	60,000
Sub-Total[6/]				
Materials and Equipment		115,500	774,600	890,100
Civil and Structural		700,800	-	700,800
		816,300	774,600	1,590,900
Total Construction Cost				
Materials and Equipment		553,800	2,768,300	3,322,100
Civil and Structural		2,478,700	50,000	2,528,700
Sub-Total		3,032,500	2,818,300	5,850,800
Contingencies				
@ 15%		332,400	306,600	639,000
@ 10%		81,600	77,500	159,100
Sub-Total		3,446,500	3,202,400	6,648,900
Engineering				
@ 10%		171,500	318,400	489,900
@ 5%		30,600	56,900	87,500
Sub-Total		3,648,600	3,577,700	7,226,300
Land[7/]		19,000	-	19,000
Total Project Cost		3,667,600	3,577,700	7,245,300

[6/] Contingencies and engineering are calculated at 10 and 5 percent, respectively. Engineering costs include 65 percent foreign exchange.

[7/] Includes land for meter, laboratory and plumbing shop facilities (1,900 sqm).

TABLE IX-4

PHASE I-B TRANSMISSION AND DISTRIBUTION PIPELINES

Pipe Number	Location/Description	Pipe Diameter (mm)	Pipe Length (m)
1	Santiago St.	100	290
2	Peñarrubia St.	100	60
3	Peñarrubia St.	100	115
4	Peñarrubia St.	100	175
7	Arellano/Aguinaldo St.	100	355
10	Peñarrubia St.	100	165
12	Washington St.	100	90
15	Peñarrubia St.	100	170
17	Washington St.	100	90
18	M. H. del Pilar St.	100	290
24	Between Villa Manzano and Magallanes St.	100	75
27	Peñarrubia St. (Extension)	100	130
28	Pratt St.	100	150
30	Partelo St.	100	230
38	Santiago St.	100	75
52	Agoncillo St.	100	100
			2,560
13	Santiago St.	150	120
14	Santiago St.	150	60
26	Magallanes St.	150	80
29	Santiago St.	150	110
31	McKinley St.	150	370
35	Abra-Kalinga Natl. Road	150	320
36	Abra-Kalinga Natl. Road	150	205
37	Rizal St.	150	160
39	Magallanes St.	150	140
41	Gonzales/Rizal St.	150	160
42	Paz/Villa Manzano St.	150	290
43	Torrijos St.	150	420
			2,435
	Total		4,995

Fire Protection

During Phase I-B, a total of 55 hectares will be provided with fire protection service by the installation of fire hydrants. This area will include 14 hectares of Bangued Poblacion, 4 hectares of Peñarrubia Poblacion and 37 hectares of other surrounding barrios. By 1990, 67 percent of Bangued Poblacion, 50 percent of Peñarrubia Poblacion and 42 percent of the total year 2000 service area will have fire protection (see Annex IX-C).

Cost Summary: Phase I-B

The cost summary for proposed construction during Phase I-B is presented in Table IX-5. Based on 1978 price levels, the total project cost for this phase is ₱2.32 million with a foreign exchange component of ₱1.16 million.

D. SECOND STAGE OF THE RECOMMENDED LONG-TERM CONSTRUCTION PROGRAM

The second stage of the recommended program includes provision of additional source, storage, transmission and distribution facilities and expansion of internal network, service connection and fire service facilities. These works will be implemented in two construction phases.

CONSTRUCTION PHASE II-A (1991-95)

Source Facilities

An additional metering element will be provided at the metering/valve chamber upstream of Peñarrubia. This will provide adequate production metering capability beyond the year 2000.

Storage

The analysis of distribution storage in Chapter VIII indicates that storage equivalent to 15.5 percent of maximum-day demand should be provided by the year 2000. The rationale for this quantity is based on the staged capacity of the proposed transmission mains. At the end of the planning period for this study, there is excess capacity in the transmission main and, therefore, the maximum quantity of storage is not required.

Based on the excess transmission main capacity, an additional 200 cum of distribution storage is required by 2000. It is recommended that this required storage be provided in construction

TABLE IX-5

COST SUMMARY FOR CONSTRUCTION
STAGE I PHASE B (1986-90)

Item	Construction Period	Cost (P) Local	Cost (P) Foreign[8/]	Cost (P) Total
Pipelines and Valves	1986-88			
(100 mm x 2,560 m)				
Materials and Equipment		15,700	111,500	
Civil and Structural		135,100	-	
(150 mm x 2,435 m)				
Materials and Equipment		66,200	256,200	
Civil and Structural		198,700	-	
Sub-Total[9/]				
Materials and Equipment		81,900	367,700	449,600
Civil and Structural		333,800	-	333,800
		415,700	367,700	783,400
Internal Network	1986-90			
Materials and Equipment		29,000	226,900	
Civil and Structural		286,500	-	
		315,500	226,900	542,400
Service Connections	1986-90			
Materials and Equipment		14,500	292,800	
Civil and Structural		197,800	-	
		212,300	292,800	505,100
Fire Hydrants	1986-90			
Materials and Equipment		16,800	57,300	
Civil and Structural		24,700	-	
		41,500	57,300	98,800
Sub-Total[10/]				
Materials and Equipment		60,300	577,000	637,300
Civil and Structural		509,000	-	509,000
		569,300	577,000	1,146,300
Total Construction Cost				
Materials and Equipment		142,200	944,700	1,086,900
Civil and Structural		842,800	-	842,800
		985,000	944,700	1,929,700
Contingencies				
@ 15%		62,400	55,200	117,600
@ 10%		56,900	57,700	114,600
Sub-Total		1,104,300	1,057,600	2,161,900
Engineering				
@ 10%		31,500	58,600	90,100
@ 5%		22,000	41,000	63,000
TOTAL PROJECT COST		1,157,800	1,157,200	2,315,000

8/ U.S. $1.00 = ₱7.00.

9/ Contingencies and engineering calculated at 15 and 10 percent, respectively. Engineering cost includes 65 percent foreign exchange.

10/ Contingencies and engineering calculated at 10 and 5 percent, respectively. Engineering cost includes 65 percent foreign exchange.

Phase II-A. The new tank should be located at the existing site. The size of the tank to be constructed in Phase II-A should be reviewed at the time of final design of the tank. It may be advisable to increase the tank size based on demand projections at that time. Studies at the time of final design may very well show that it would be more economical to increase the size to serve for a longer period.

Transmission Facilities

A second 200 mm transmission pipeline extending from Lusuac Spring to the existing storage reservoir site (7,890 meters) will be constructed during Phase II-A (1993-94). This pipeline, together with the additional storage reservoir also to be constructed during Phase II-A, will provide adequate source/transmission capacity to the year 2000.

Distribution System

The majority of the distribution system improvements recommeded for construction during Phase II-A are designed to serve the barrios of Agtañgao, Palao and Sao-atan. The remainder of the distribution improvements are designed to reinforce the system between the distribution storage tank and the Bangued poblacion. Table IX-6 lists the improvements recommended for construction during Phase II-A and Figures IX-6, IX-7 and IX-1 (appended) show the pipelines included in Phase II-A.

TABLE IX-6

PHASE II-A TRANSMISSION AND DISTRIBUTION PIPELINES

Pipe Number	Location/Description	Pipe Diameter (mm)	Pipe Length (m)
302	Bo. Agtañgao Road	100	400
303	Bo. Palao Road	100	400
			800
301	Bo. Sao-atan Road	150	300
48	Transmission Pipeline to Reservoir	200	4,950
50	Transmission Pipeline to Reservoir	200	2,940
117	From Reservoir to Torrijos St.	200	605
118	From Reservoir to Torrijos St.	200	120
119	From Reservoir to Torrijos St.	200	175
			8,790
		Total	9,890

Internal Network

An additional 34 hectares of internal network will be provided during Phase II-A. This will provide service to 50 percent of the additional area to be served between 1990 and 2000, resulting in service to about 85 percent of the year 2000 service area.

Service Connections

An additional 879 service connections will be installed during Phase II-A, at an annual rate of approximately 180 connections per year. By 1995, the BAN-WD will have 3,450 service connections.

Fire Protection

During Phase II-A, a total of 63 hectares will be provided with fire protection service by the installation of fire hydrants. This area will include 14 hectares of Bangued poblacion, 4 hectares of Peñarrubia poblacion and 45 hectares of other surrounding barrios. By 1995, 83 percent of Bangued poblacion and 75 percent of Peñarrubia poblacion, or 75 percent of the total year 2000 service area, will have fire protection.

Laboratory Facilities

As the BAN-WD increases in size, the number of samples will grow and the laboratory may be utilized for other agencies within the municipality. The laboratory will purchase additional equipment including some more sophisticated analytical devices during Phase II-A (1994-95).

Water Meter Test/Repair Facilities

The number of metered connections in the BAN-WD will increase to a point in Phase II-A that the facilities provided in 1981-82 will not be adequate. A duplicate set of test benches, test tanks, repair benches and tools will be purchased during Phase II-A to meet the needs of the BAN-WD through 2000.

Cost Summary - Phase II-A

A cost summary for construction during Phase II-A is presented in Table IX-7, based on 1978 price levels. The total project cost for this phase is ₱6.12 million, with a foreign exchange component of ₱2.87 million.

CONSTRUCTION PHASE II-B (1996-2000)

Internal Network

Additional 51 hectares of internal network will be provided during Phase II-B. By the year 2000, 100 percent of the year 2000

TABLE IX-7

COST SUMMARY FOR CONSTRUCTION
STAGE II PHASE A (1991-95)

Item	Construction Period	Cost (₱) Local	Foreign[11]	Total
Source Facilities	1991-92			
Materials and Equipment		-	30,000	
Civil and Structural		3,000	-	
		3,000	30,000	33,000
Storage Facilities	1992-93			
Materials and Equipment		689,300	229,900	
Civil and Structural		271,600	-	
		960,900	229,900	1,190,800
Pipelines and Valves	1991-92			
(100 mm x 800 m)				
Materials and Equipment		5,300	36,700	
Civil and Structural		44,100	-	
(150 mm x 300 m)				
Materials and Equipment		7,500	28,900	
Civil and Structural		22,800	-	
(200 mm x 8,790 m)				
Materials and Equipment		284,700	1,119,200	
Civil and Structural		751,000	-	
		1,115,400	1,184,800	2,300,200
Laboratory Facilities	1994-95			
Materials and Equipment		16,800	65,000	
Civil and Structural		13,500	50,000	
		30,300	115,000	145,300
Meter Repair Facilities	1991-92			
Materials and Equipment		4,400	55,000	
Civil and Structural		10,000	-	
		14,400	55,000	69,400
Sub-Total[12]				
Materials and Equipment		1,008,000	1,564,700	2,572,700
Civil and Structural		1,116,000	50,000	1,166,000
		2,124,000	1,614,700	3,738,700
Internal Network	1991-95			
Materials and Equipment		18,200	142,600	
Civil and Structural		180,000	-	
		198,200	142,600	340,800

[11] U.S. $1.00 = ₱7.00.

[12] Contingencies and engineering calculated at 15 and 10 percent, respectively.

TABLE IX-7 (Continued)

Item	Construction Period	Cost (P) Local	Foreign	Total
Service Connections	1991-95			
Materials and Equipment		21,100	425,900	
Civil and Structural		287,800	-	
		308,900	425,900	734,800
Fire Hydrants	1991-95			
Materials and Equipment		18,400	62,700	
Civil and Structural		27,000	-	
		45,400	62,700	108,100
Sub-Total[13/]				
Materials and Equipment		57,700	631,200	688,900
Civil and Structural		494,800	-	494,800
		552,500	631,200	1,183,700
Total Construction Cost				
Materials and Equipment		1,065,700	2,195,900	3,261,600
Civil and Structural		1,610,800	50,000	1,660,800
		2,676,500	2,245,900	4,922,400
Contingencies				
@ 15%		318,600	242,200	560,800
@ 10%		55,200	63,100	118,300
	Sub-Total	3,050,300	2,551,200	5,601,500
Engineering[14/]				
@ 10%		150,500	279,500	430,000
@ 5%		22,800	42,300	65,100
	Sub-Total	3,223,600	2,873,000	6,096,600
Land[15/]		20,000	-	20,000
Total Project Cost		3,243,600	2,873,000	6,116,600

13/ Contingencies and engineering calculated at 10 and 5 percent, respectively.

14/ Engineering costs consist of 65 percent foreign exchange currency.

15/ Includes land for storage tank (400 sqm).

service area will have access to water supply via the internal network system installed by that time.

Service Connections

During Phase II-B, a total of 880 service connections will be installed, at the rate of 180 connections per year. By the year 2000, the BAN-WD will have a total of 4,332 connections.

Fire Protection

During Phase II-B, a total of 63 hectares will be provided with fire protection service by fire hydrant installation. This area will include 14 hectares of Bangued poblacion, 4 hectares of Peñarrubia poblacion and 45 hectares of other surrounding barrios. By 2000, fire protection will be provided to 100 percent of the poblaciones of Bangued and Peñarrubia, 50 percent of the barrios of Lipcan, Dangdangla, Calaba, Bangbangar, Patucannay and Riang, and 30 percent of the barrios of Agtañgao, Sao-atan, and Palao.

Cost Summary - Phase II-B

A cost summary for construction during Phase II-B is presented in Table IX-8. Based on 1978 price levels, the total project cost of this phase is ₱1.56 million, with a foreign exchange component of ₱0.82 million.

E. CAPITAL COST SUMMARY

The capital costs for each phase of the long-term construction program, including the immediate improvement program, are summarized in Table IX-9. The total project costs shown in this table include engineering, contingencies and land costs. All construction cost estimates are based on 1978 price levels. The foreign exchange component of the total project cost includes the costs of direct and indirect import items.

F. ANNUAL OPERATION AND MAINTENANCE COSTS

Annual operation and maintenance costs include personnel, power, chemicals, maintenance, rentals, office supplies and other miscellaneous expenses which are necessary to sustain the overall water supply system. The total annual budgeted cost of the existing system in 1976 was ₱49,000. Following implementation of the proposed improvements and new construction program, the annual costs will increase due to the additional costs for personnel, chemicals and maintenance.

TABLE IX-8

COST SUMMARY FOR CONSTRUCTION
STAGE II PHASE B (1996-2000)

Item	Construction Period	Cost (₱) Local	Cost (₱) Foreign[16]	Cost (₱) Total
Internal Network	1996-2000			
Materials and Equipment		27,400	213,900	
Civil and Structural		270,000	-	
		297,400	213,900	511,300
Service Connections	1996-2000			
Materials and Equipment		21,100	425,900	
Civil and Structural		287,800	-	
		308,900	425,900	734,800
Fire Hydrants	1996-2000			
Materials and Equipment		18,400	62,700	
Civil and Structural		27,400	-	
		45,800	62,700	108,500
Total Construction Cost				
Materials and Equipment		66,900	702,500	769,400
Civil and Structural		585,200	-	585,200
Sub-Total		652,100	702,500	1,354,600
Contingencies @ 10%		65,200	70,300	135,500
Sub-Total		717,300	772,800	1,490,100
Engineering[17] @ 5%		26,100	48,400	74,500
TOTAL PROJECT COST		743,400	821,200	1,564,600

16/ US $1.00 to ₱7.00.

17/ Engineering cost is assumed to be 65 percent FEC.

The annual costs of operating and maintaining the water district facilities are estimated to be ₱150,000, ₱290,000 and ₱407,000 in 1980, 1990 and 2000, respectively. The estimated breakdown of these costs is shown in Table IX-10. All costs shown are based on projected 1978 price levels.

TABLE IX-9

CAPITAL COST SUMMARY

Construction Phase	Construction Period	Construction Cost (₱)	Project Cost (₱) Local	FEC	Total
Immediate Improvement Program	1977-79	2,708,100	1,766,400	1,743,300	3,509,700
I-A	1980-85	5,850,800	3,667,600	3,577,700	7,245,300
I-B	1986-90	1,929,700	1,157,800	1,157,200	2,315,000
II-A	1991-95	4,922,400	3,243,600	2,873,000	6,116,600
II-B	1996-2000	1,354,600	743,400	821,200	1,564,600
Total		16,765,600	10,578,800	10,172,400	20,751,200

TABLE IX-10

ANNUAL OPERATION AND MAINTENANCE COSTS

Item	Annual Costs (₱)[18/] 1976	1980	1990	2000
Administration and Personnel	36,300	100,200	185,900	238,600
Power and Fuel	-	13,200	13,200	13,200
Chemicals	1,000	6,600	13,100	22,000
Maintenance	7,300	24,300	63,900	97,700
Miscellaneous	4,400	5,300	13,700	35,500
	49,000	149,600	289,800	407,000

18/ Computed at 1978 price levels.

G. SEWERAGE/DRAINAGE CONCEPTS

Existing Drainage System

The existing drainage facilities in Bangued drain the eastern portion of the area into Sinalang Creek, the central portion into Sinapangan Creek and the western portion (together with the fringes of the central portion) into surrounding low-lying cultivated fields.

The existing facilities consist of a system of open canals along most of the municipality's streets (see Figure IX-8). These street drains are unline earthen ditches varying in width from 0.3 to 1.0 meter and from 0.3 to 1.5 meters deep. Most of these street drains are interconnected at street intersections by 0.3 meter drainage culverts.

Although the existing facilities are intended for drainage into the available natural surface water channels, many of the street drains overflow during rainy periods, with resultant overland flow to surrounding rice fields.

Improvements to the existing drainage system are impeded by lack of sufficient municipal staff, insufficiency of allocated funds and the absence of a long-term drainage master plan. The existing system in the past was improved or extended according to the growth patterns and road development within the community. Although street sweepers employed by the municipal government maintain the street drains in the vicinity of the town plaza, the majority of street drains are maintained by local residents. Road intersection drainage culverts are virtually not maintained (and are, therefore, usually clogged and of little use during storms).

The existing drainage facilities were constructed for the collection and disposal of stormwater run-off. Most of the street canals are dry during non-rainy periods. During rainy periods, surface run-off, as well as some miscellaneous solid waste materials, is carried by the street canals, with very little domestic sewage entering the system.

Field observations of the drainage system in Bangued are as follows:

1. The major disposal areas for stormwater run-off are the Sinalang and Sinapangan Creeks and surrounding cultivated fields, for the eastern, central and western portions of

the municipal area, respectively. The flows of the Sinalang and Sinapangan Creeks ultimately enter the Abra River, 3-4 km from the center of the municipality.

2. Domestic wastewater is discharged into septic tanks and pit privies. Some roof drainage is transported to these facilities, with occasional flooding during rainy periods. Although direct discharge of domestic wastewater to storm water facilities is uncommon, it is likely that an appreciable amount of domestic wastewater travels overland during rainy periods.

3. The public market and slaughterhouse drain their wastewaters directly into the Sinapangan Creek.

4. Although nominally the responsibility of the municipality, the limited quantity of available resources makes drainage system development and maintenance impractical.

5. There are no existing industries producing significant wastewaters.

6. Approximately 30 cumd of solid wastes is collected by the municipality, and disposed of (dumped and burned) adjacent to the Abra River northwest of the poblacion.

7. Clogging of drainage conduits is caused by deposition of locally eroded soils, the dumping of solid wastes into drainage channels and lack of any significant maintenance.

8. No significant flooding problems have been experienced in Bangued. Periodic flooding does occur along Partelo Street, but persists only for very short periods.

Relationship with Infrastructure and Other Engineering and Economic Factors

The provision of sewerage and drainage facilities within the BAN-WD has a significant impact on water supply and other infrastructure components. Economics (public's ability-to-pay) and the status of public health directly affect the feasibility of providing sewerage and drainage facilities.

In view of the current relatively minor storm water drainage problems being experienced in the BAN-WD area, it appears that drainage facilities do not warrant high priority in Bangued's list of infrastructure components. Before decisions can be made concerning the implementation of sewerage and/or drainage programs, additional technical and economic data must be collected and evaluated.

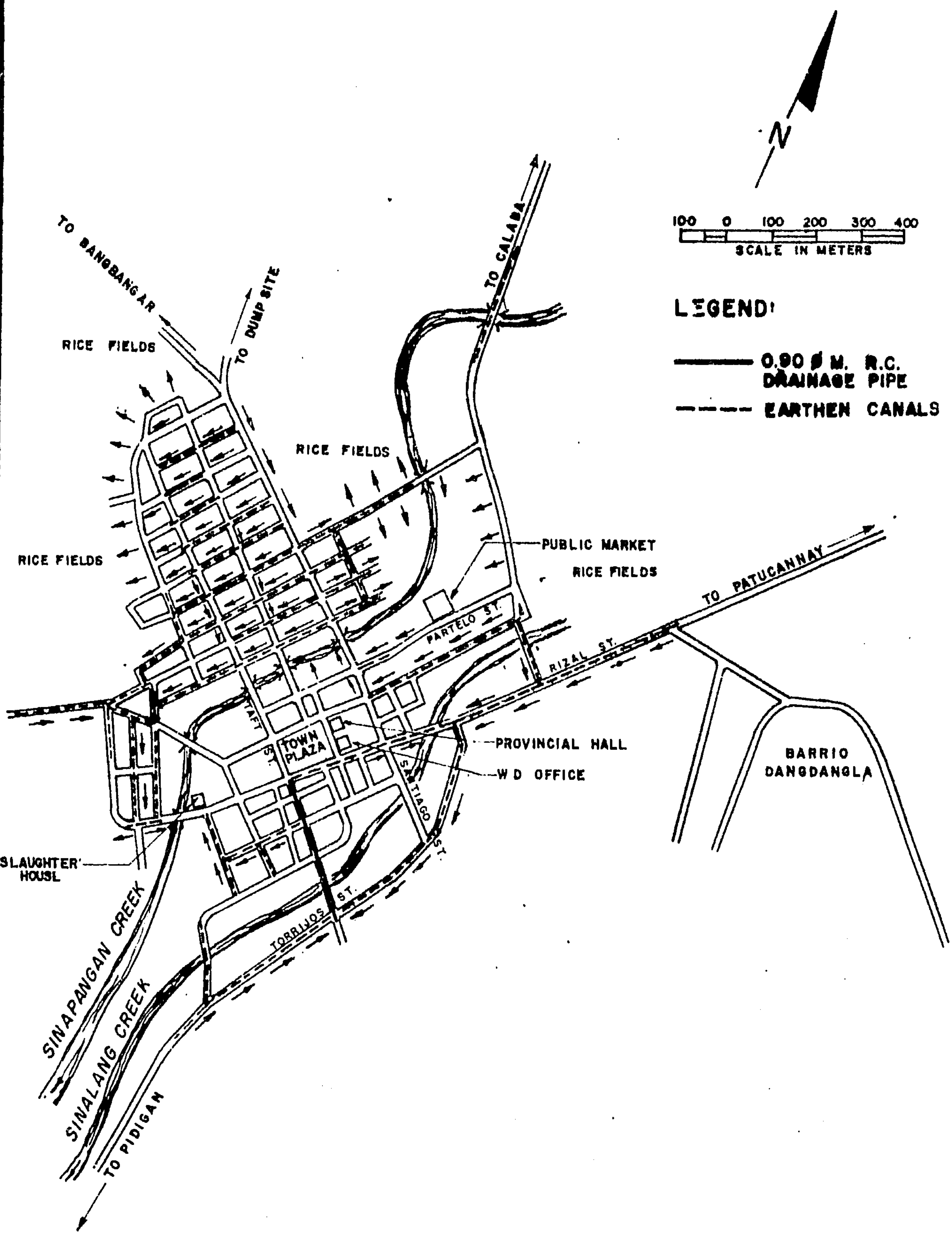


FIGURE IX-8
EXISTING
SEWERAGE/DRAINAGE FACILITIES
SCHEMATIC
BANGUED WATER DISTRICT

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

Information from the Department of Health indicates that in 1975, 18 percent of Bangued households had water-borne toilet facilities, 60 percent had closed-pit type toilets, 2 percent had open-pit toilets and 20 percent had no toilet facilities. It is unlikely that such a low percentage of "modern" facilities can economically justify a near-future sewerage program.

The rationale for the provision of wastewater facilities has traditionally been based on aesthetics and public health benefits. At present, there is an obvious water supply problem in the BAN-WD. As the water supply problem is resolved, wastewater volumes will increase. Related aesthetic and public health standards will improve in time, increasing the urgency for solution of the wastewater problem.

Projected Wastewater Volumes

Wastewater flows in BAN-WD have been projected for the years 1990, 2005 and 2025. These estimates are shown in Table IX-11.

The service area considered for the wastewater projections was the core area to receive water supply by 1980. This area is the most densely populated area in the water district, and is the area where public health and nuisance problems associated with wastewater will be greatest.

The wastewater volume which could be collected was determined by estimating the percentage of water supply connections (domestic and commercial/industrial/institutional) with sewer connections during the design period from 1990 to 2025. It was assumed that all water supply connections will have sewer connections by 2025, and that in 1990, 30 percent of domestic and 50 percent of commercial/industrial/institutional water supply connections will have sewer connections. It was assumed that no unusually large water-consuming connections will occur during the design period, and that 90 percent of water consumed will, therefore, be returned to the sewers. An allowance was made for groundwater infiltration into the sewers, based on projected percentage of physical area with sewers and an infiltration rate of 0.15 lps/hectare. The resultant number of sewer connections required during the design period was then checked to ensure that the annual rate of sewer connections was realistically within the capabilities of the water district.

Alternatives Available

The cost of sewerage/drainage facilities for the BAN-WD area is expected to be significant.

The provision of a financially self-sufficient sewerage/drainage system is seldom achieved, even in developed countries. It is likely that the BAN-WD is no exception to this rule.

TABLE IX-11

AVERAGE DAILY WASTEWATER FLOWS
BANGUED WATER DISTRICT

Served Area	Design Year	Wastewater Flows (cumd)			
		Domestic	Commercial/ Industrial/ Institutional	Infiltration Allowance	Total
Bangued Poblacion	1990	494	115	531	1,140
	2005	1,611	388	765	2,764
	2025	5,578	1,228	1,062	7,868
Lipcan	1990	29	7	162	198
	2005	95	23	233	351
	2025	329	72	324	725
Peñarrubia Poblacion	1990	18	4	117	139
	2005	58	14	168	240
	2025	199	44	233	476
Dumayco	1990	18	4	65	87
	2005	59	14	93	166
	2025	203	45	130	378
Total	1990	559	130	875	1,564
	2005	1,823	439	1,259	3,521
	2025	6,309	1,389	1,749	9,447

Feasible alternatives for sewerage in BAN-WD area appear to be as follows:

1. individual (septic tanks) or unified public collection system;

2. combined or separate sewerage/drainage systems;

3. various degrees of centralized community sewage treatment;

4. disposal system (river or land treatment) for treated sewage.

The question of whether the BAN-WD should construct a combined or a separate sewerage/drainage system depends on economic circumstances.

An alternative to the combined system which must be investigated in detail during the sewerage feasibility study is the provision of open canals (peripheral drains).

Alternative treatment and disposal methods for intercepted wastewater may consist of:

1. Screening of gross solids, high-rate lagoons and effluent discharge into the Abra River;

2. Some form of treatment such as conventional primary or high-rate secondary treatment may be applied.

Treated wastes may be used potentially for agricultural irrigation.

Recommendations

As soon as the first-phase of the water supply program is underway, a comprehensive sewerage/drainage feasibility study should be undertaken. This study must address the issue of combined versus separate sewers. It should also update the population and water demand projections of this water supply study.

Once the decision has been made to use either the combined or separate system, the water district must embark as promptly as possible on a street sewering and house connection program.

A plumbing code should be developed by the BAN-WD to coordinate plumbing requirements for water, wastewater and surface runoff facilities. This code becomes very important and meaningful particularly if a separate system of sewers is adopted.

In the meantime, a house-to-house survey should be conducted to inventory existing wastewater and toilet facilities. As-built drawings of storm drains and peripheral canals must be compiled and accurately recorded in preparation for the sewerage/drainage feasibility study.

For residences and establishments that currently lack waste disposal facilities and are financially unable to provide the modern flush toilet with septic tank, the Department of Health (Division of Environmental Sanitation) has developed an inexpensive water-seal toilet.

Permanent rights-of-way should be acquired for the main canals that will be used for drainage/sewerage canals.

Dumping solid wastes into waterways and canals should be strictly prohibited. Solid wastes not only pollute the water, but also are very unsightly and serve as habitats for flies, rodents and parasites. The proper handling of solid wastes should be studied and planned carefully.

H. MANAGEMENT OF WATER RESOURCES

In order to make the best use of water resources available for present and future demands of the BAN-WD, certain technical and management steps must be considered. These considerations are primarily related to the collection of data concerning the chemical quality and amount of water produced by the district, and a data storage and retrieval system which would be accessible to those organizations dealing with the subject. These are discussed further in Appendices M and P, Volume II of this report.

I. UPDATING THE WATER SUPPLY MASTER PLAN

To be a meaningful working document, this water supply master plan must be periodically updated. Changes related to technological developments, social goals, land use concepts, unforeseen population growth or movement, etc., must be reviewed for possible long-range impact on the programs recommended in this report. An outline of the steps required for such periodic updating is presented in Appendix Q, Volume II.

J. ENVIRONMENTAL CONSIDERATIONS

Appendix R, Volume II discusses some of the ways the recommended program may affect the environment of the study area. Some natural resources affected by the program are irreplaceable, requiring due consideration before actual construction.

ANNEX IX-C

DISTRIBUTION SYSTEM GROWTH

ANNEX IX-C

DISTRIBUTION SYSTEM GROWTH

General

It is necessary to project the growth of the distribution system in order to estimate the required expenditures for internal network piping, service connections, and fire hydrant requirements. The projection of distribution system growth is based on (1) an apportionment of the served population among individual sections within the service area, (2) the projected number of people served by each connection, and (3) the anticipated total area of individual served sections within the service area. The details of these items are discussed below.

Served Population

The projections of served population presented in Chapter VI are presented in Annex Table IX-C-1 according to individual community served and respective service areas in 1976, 1980, 1990 and 2000.

Number of People Per Connection

Based on the pilot area studies within the present service area, it is anticipated that the future number of persons served by a single service connection will be 8.

Total Served Area for Individual Communities

The total areas of individual served communities have been projected on the basis of field studies and locations with potential consumers of the BAN-WD water supply. These projections are presented in Annex Table IX-C-2.

Area Served By Internal Network System

In order to project the net area to be served by internal network, the gross served areas were reduced in proportion to the expected percentage of population served (see Annex Table IX-C-3).

The reduced served areas were further reduced based on the assumption that (1) some of the distribution system pipes included in the analyses are actually internal network; and (2) some of the proposed distribution pipelines will serve as equivalent internal network. It has been assumed that relevant distribution system

ANNEX TABLE IX-C-1

SERVED POPULATION PROJECTIONS
BANGUED WATER DISTRICT

Community Served	1976 Service Area	1980 Service Area	1990 Service Area	2000 Service Area
Bangued Poblacion	6,320	8,720	14,015	20,420
Peñarrubia Poblacion	85	312	675	1,060
Bo. Dumayco	120	318	530	870
Bo. Lipcan	195	515	900	1,395
Bo. Dangdangla	-	255	390	670
Bo. Riang	-	-	150	395
Bo. Calaba	-	-	745	1,455
Bo. Bangbangar	-	-	350	900
Bo. Patucannay	-	-	635	1,365
Bo. Agtañgao	-	-	-	575
Bo. Sao-atan	-	-	-	275
Bo. Palao	-	-	-	640
Total Served Population	6,720	10,120	18,390	30,020
Total Service Area Population	10,840	14,350	23,700	35,440
Percent Served	62	71	78	85

ANNEX TABLE IX-C-2

TOTAL SERVED AREA FOR INDIVIDUAL COMMUNITIES (ha)

Community Served	1976 Service Area	1980 Service Area	1990 Service Area	1990 Service Area
Bangued Poblacion	82	82	82	82
Peñarrubia Poblacion	18	18	18	18
Bo. Dumayco	10	10	24	24
Bo. Lipcan	25	25	25	32
Bo. Dangdangla	-	20	20	20
Bo. Riang	-	-	10	10
Bo. Calaba	-	-	40	40
Bo. Bangbangar	-	-	30	30
Bo. Patucannay	-	-	45	45
Bo. Agtañgao	-	-	-	30
Bo. Sao-atan	-	-	-	18
Bo. Palao	-	-	-	25
Total	135	155	294	374

ANNEX TABLE IX-C-3

REDUCED AREA (HECTARES) TO RECEIVE INTERNAL NETWORK, BY SERVICE AREA

	1976 Service Area	1980 Service Area	1990 Service Area	2000 Service Area
Total area served[1/] (ha)	135	155	294	374
Population served[2/] (%)	62	71	78	85
Reduced area served[3/] (%)	65	75	80	90
Reduced area served (ha)	88	116	235	337

pipelines can serve an area within 50 meters on each side of the pipeline, and that transmission pipelines will not provide direct service to any consumers.

It has been further assumed that regions within the 1976 and 1980 service areas will not be fully served until 1985 and that the balance of the 1990 service area will be provided with internal network between 1990 and 2000.

The net areas to receive internal network are tabulated in Annex Table IX-C-4, according to construction phase.

Number of Service Connections

The number of service connections to be installed is obtained by dividing the served population by the average number of persons per connection. The estimated number of service connections for each community within the service area is presented in Annex Table IX-C-5.

During the leakage survey to be conducted during the immediate improvement program, it is expected that some existing service connections will be identified as major sources of leakage. It has therefore been anticipated that 30 percent of existing service connections will require major repair or replacement by 1980.

1/ See Annex Table IX-C-2
2/ See Annex Table IX-C-1
3/ Assumed

ANNEX TABLE IX-C-4

NET AREA (HECTARES) TO RECEIVE INTERNAL NETWORK
(BY CONSTRUCTION PHASE)

	Construction Phase			
	I-A	I-B	II-A	II-B
Reduced Area to Receive Internal Network				
1976 Service Area 4/	44	-	-	-
1980 Service Area	28	-	-	-
1990 Service Area	65	54	-	-
2000 Service Area	-	-	51	51
Sub-total	137	54	51	51
Allowance for Other	49	-	17	-
Net Area to Receive Internal Network	88	54	34	51
Cumulative Total Area with Equivalent Internal Network	181	235	286	337

ANNEX TABLE IX-C-5

SCHEDULE FOR SERVICE CONNECTION INSTALLATION

Location	Immediate Improvement	Phase I-A (1981-85)	Phase I-B (1986-90)	Phase II-A (1991-95)	Phase II-B (1996-2000)
Bangued Poblacion (790)*	300	331	331	400	400
Peñarrubia Poblacion (18)*	47	38	38	40	40
Bo. Dumayco (23)*	37	19	20	32	33
Bo. Lipcan (37)*	60	36	36	47	47
Bo. Dangdangla	50	13	13	28	27
Bo. Calaba	-	68	67	65	65
Bo. Bangbangar	-	27	28	43	43
Bo. Patucannay	-	60	60	68	69
Bo. Riang	-	13	13	21	21
Bo. Agtañgao	-	-	-	52	53
Bo. Sao-atan	-	-	-	26	25
Bo. Palao	-	-	-	57	57
Total	494	605	606	879	

4/ 50 percent of 1976 service area is served by existing internal network.
* Numbers in parentheses indicate existing connections in 1976.

Areas to Receive Fire Protection

Because of the financial impact of the overall construction program on the consumers within the service area, it is proposed that only the poblaciones of Bangued and Peñarrubia and Barrio Dumayoo receive complete fire protection coverage (100 percent) by the year 2000. Barrios Lipcan, Dangdangla, Calaba, Bangbangar, Patucannay and Riang will receive 50 percent coverage; barrios Agtañgao, Sao-atan and Palao will receive 30 percent coverage. All of the communities within the service area, except Bangued Poblacion, will be provided with the normal residential type of hydrant coverage. Bangued Poblacion, because of higher population densities and generally higher property values associated with commercial areas, will be provided with a higher level of hydrant service. The costs for fire hydrant installation are included in the cost tables of Chapter IX.

It should be noted that if a community does not receive full fire hydrant coverage, it still has been provided with full fire-flow piping capacity. The pipelines have been designed to provide the required fire flow to all communities whether the hydrants are installed immediately or not.

ANNEX TABLE IX-C-6

SCHEDULE FOR FIRE HYDRANT INSTALLATION

Location	Area (ha) Receiving Fire Protection			
	Phase I-A	Phase I-B	Phase II-A	Phase II-B
Bangued Poblacion 5/	32.8	13.6	13.6	13.6
Peñarrubia Poblacion	4.9	4.1	4.5	4.5
Bo. Dumayoo	6.8	5.7	5.7	5.7
Bo. Lipcan	9.1	7.6	7.6	7.6
Bo. Dangdangla	2.9	2.4	2.4	2.4
Bo. Calaba	1.2	6.2	6.2	6.2
Bo. Bangbangar	0.9	4.7	4.7	4.7
Bo. Patucannay	1.4	7.0	7.0	7.0
Bo. Riang	0.3	1.6	1.6	1.6
Bo. Agtañgao	-	0.8	4.1	4.1
Bo. Sao-atan	-	0.5	2.4	2.4
Bo. Palao	-	0.7	3.4	3.4
Total	60.3	54.9	63.2	63.2
Cumulative Total	68.5	123.4	186.6	249.8

5/ It is estimated that approximately 10 percent (8.2 ha) of the total poblacion is currently covered by effective fire hydrant service.

Computer Studies

The recommended program of pipe construction in Chapter IX reflects the results of successive computer analyses on the BAN-WD distribution system. The general design criteria and method of analysis are discussed in Appendix K of Volume II and Chapter XII of the Methodology Manual.

The method of selecting pipeline sizes consists of analyzing a number of flow requirements and operating conditions and designing each pipe for the worst set of conditions. Since each computer analysis is critical to a different series of pipes there is no single program result that can be included herein as a "design run".

The computer printouts for the peak-hour and minimum-hour conditions are shown in Annex Tables IX-C-7 and IX-C-8 as representative of the worst conditions for pipe design. The peak-hour condition can, in general, be considered as the "design run" for the majority of pipes. However, certain variations in operational modes, especially in systems with well supplies, can be more critical for some pipelines.

The pipeline and node numbers on the computer printouts are the same as those in Figures IX-6 and IX-7. In general, pipes of series 0 to 99 are existing pipelines, pipes 100 to 199 are immediate improvements, pipes 200 to 299 are Phase 1 improvements and pipes 300 to 399 are Phase II improvements. Pipes 400 to 499 are existing pipelines that would be replaced with new pipes in Phase I.

ANNEX TABLE IX-C-7
COMPUTER PRINTOUT (BAN-WD)
YEAR 2000 PEAK HOUR

BANGUED 2000 PEAK HOUR

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INPUT AND OUTPUT IN                 LPS
NO OF NODES                          55
NO OF PIPES                          70
MAX NO OF ITERATIONS                 20
PEAKING FACTOR                  1.75000
ALLOW P-DROP FR/STATIC - PCT       50.0
STATIC HGL FOR P-DROP CALC        103.5
MAX UNBAL - LPS                 0.05000
MAX ALLOW VEL -MPS                3.000
MIN ALLOW VEL - MPS               0.400
MAX ALLOW HL -  M/1000 M          10.00
MIN ALLOW HL -  M/1000 M           0.30
MAX ALLOW PRESS - ATM             7.000
MIN ALLOW PRESS - ATM             0.700
NO OF HEADS TO BE READ                2
NO OF UNKNOWN CONSUMPTIONS            2
SUM OF FIXED DEMANDS             109.81
BANDWIDTH                             5
ITER  1 UNBAL 1917.14 LPS
ITER  2 UNBAL 1034.57 LPS
ITER  3 UNBAL  474.87 LPS
ITER  4 UNBAL  216.74 LPS
ITER  5 UNBAL   97.09 LPS
ITER  6 UNBAL   39.93 LPS
ITER  7 UNBAL   11.92 LPS
ITER  8 UNBAL    1.39 LPS
ITER  9 UNBAL    0.02 LPS

SOLUTION NO. 1 REACHED IN   9 ITERATIONS
        0.0197 GPM UNBALANCE
```

ANNEX TABLE IX-C-7 (continued)

PIPE NO	NODES FROM	NODES TO	DIA MM	L MTRS	H-W C	K-VALUE	FLOW	--VEL-- MPS	CK	--HEADLOSS--- MT	MT/1000	CK
401	11	1	100	290.	100	0.125E 00	5.07	0.65		2.53	8.72	
402	3	2	100	60.	100	0.259E-01	0.73	0.09	LO	0.01	0.24	LO
403	5	3	100	115.	100	0.495E-01	1.37	0.17	LO	0.09	0.77	
404	5	10	100	175.	100	0.754E-01	0.62	0.08	LO	0.03	0.18	LO
405	6	5	150	100.	100	0.598E-02	3.15	0.18	LO	0.05	0.50	
407	7	6	100	355.	100	0.153E 00	1.50	0.19	LO	0.33	0.92	
408	43	11	150	165.	100	0.987E-02	8.33	0.47		0.50	3.03	
409	44	43	150	230.	100	0.138E-01	3.80	0.22	LO	0.16	0.71	
410	10	44	100	165.	100	0.711E-01	1.47	0.19	LO	0.15	0.88	
412	8	7	100	90.	100	0.388E-01	3.71	0.47		0.44	4.87	
413	16	43	150	120.	100	0.718E-02	6.84	0.39	LO	0.25	2.11	
414	17	16	150	60.	100	0.359E-02	10.44	0.59		0.28	4.60	
415	18	44	100	170.	100	0.732E-01	3.10	0.39	LO	0.60	3.51	
417	29	7	100	90.	100	0.388E-01	0.68	0.09	LO	0.02	0.21	LO
418	32	29	100	290.	100	0.125E 00	2.80	0.36	LO	0.84	2.90	
419	32	31	150	90.	100	0.538E-02	5.78	0.33	LO	0.14	1.54	
420	28	32	150	180.	100	0.108E-01	10.71	0.61		0.87	4.83	
421	27	28	150	105.	100	0.628E-02	12.39	0.70		0.66	6.32	
422	23	25	200	40.	110	0.494E-03	1.80	0.06	LO	0.00	0.04	LO
423	25	27	200	70.	110	0.864E-03	5.44	0.17	LO	0.02	0.28	LO
424	26	25	100	75.	100	0.323E-01	4.08	0.52		0.44	5.81	
425	24	23	200	75.	110	0.926E-03	40.05	1.27		0.86	11.46	HI
426	23	22	150	80.	100	0.478E-02	11.56	0.65		0.44	5.56	
427	22	19	100	130.	100	0.560E-01	4.89	0.62		1.06	8.13	
428	19	18	100	150.	100	0.646E-01	4.06	0.52		0.87	5.78	
429	20	17	150	110.	100	0.658E-02	17.28	0.98		1.29	11.71	HI
430	16	55	100	230.	100	0.991E-01	2.04	0.26	LO	0.37	1.61	
431	17	15	150	370.	100	0.221E-01	5.53	0.31	LO	0.53	1.42	
432	15	14	100	65.	100	0.280E-01	3.99	0.51		0.36	5.59	
433	14	12	100	310.	100	0.134E 00	3.91	0.50		1.67	5.39	
434	12	13	150	640.	100	0.383E-01	8.03	0.45		1.81	2.83	
435	45	38	150	320.	100	0.191E-01	9.83	0.56		1.32	4.12	
436	37	45	150	205.	100	0.123E-01	9.83	0.56		0.85	4.12	
437	37	20	150	160.	100	0.957E-02	13.04	0.74		1.11	6.95	
438	21	20	100	75.	100	0.323E-01	5.08	0.65		0.66	8.75	
439	22	21	150	140.	100	0.837E-02	5.71	0.32	LO	0.21	1.51	
440	36	24	200	130.	110	0.161E-02	46.17	1.47		1.94	14.92	HI
441	33	27	150	160.	100	0.957E-02	7.67	0.43		0.42	2.60	
442	34	33	150	290.	100	0.173E-01	8.78	0.50		0.97	3.34	
443	34	35	150	420.	100	0.251E-01	8.87	0.50		1.43	3.41	
448	52	42	200	4950.	110	0.611E-01	39.07	1.24		54.20	10.95	HI
449	52	42	200	4950.	110	0.611E-01	39.07	1.24		54.20	10.95	HI
450	53	52	200	2940.	110	0.363E-01	43.32	1.38		38.98	13.26	HI
451	53	52	200	2940.	110	0.363E-01	43.32	1.38		38.98	13.26	HI
101	4	2	100	100.	100	0.431E-01	0.04	0.01	LO	0.00	0.00	LO
102	6	4	100	180.	100	0.776E-01	1.44	0.18	LO	0.15	0.85	
103	9	6	150	170.	100	0.102E-01	7.52	0.43		0.43	2.51	
104	9	10	150	95.	100	0.568E-02	11.32	0.64		0.51	5.35	
105	10	11	150	220.	100	0.132E-01	9.24	0.52		0.81	3.68	
106	11	12	150	460.	100	0.275E-01	8.76	0.50		1.53	3.33	

ANNEX TABLE IX-C-7 (continued)

PIPE NO	NODES FROM	NODES TO	DIA MM	L MTRS	H-W C	K-VALUE	FLOW	--VEL-- MPS	--CK	--HEADLOSS--- MT	MT/1000	CK
107	8	9	200	110.	110	0.136E-02	19.66	0.63		0.34	3.07	
108	23	8	200	410.	110	0.506E-02	25.08	0.80		1.98	4.82	
109	29	30	100	110.	100	0.474E-01	0.26	0.03	LO	0.00	0.04	LO
110	31	30	100	270.	100	0.116E 00	2.65	0.34	LO	0.71	2.61	
111	26	33	100	150.	100	0.646E-01	0.77	0.10	LO	0.04	0.26	LO
112	24	26	100	40.	100	0.172E-01	5.65	0.72		0.43	10.63	HI
113	55	14	100	150.	100	0.646E-01	2.04	0.26	LO	0.24	1.61	
114	36	37	200	530.	110	0.654E-02	27.35	0.87		3.00	5.66	
115	36	34	200	330.	110	0.407E-02	23.72	0.76		1.43	4.35	
116	38	39	100	1040.	100	0.448E 00	1.63	0.21	LO	1.10	1.06	
117	42	41	300	605.	110	0.104E-02	78.14	1.11		3.32	5.49	
118	40	36	300	120.	110	0.206E-03	101.31	1.43		1.06	8.87	
119	41	40	300	175.	110	0.300E-03	101.31	1.43		1.55	8.87	
201	38	46	150	1250.	100	0.748E-01	3.34	0.19	LO	0.70	0.56	
202	13	47	150	1000.	100	0.598E-01	5.32	0.30	LO	1.32	1.32	
203	1	48	150	1300.	100	0.777E-01	2.20	0.12	LO	0.34	0.26	LO
204	52	54	150	1100.	100	0.658E-01	1.43	0.08	LO	0.13	0.12	LO
301	35	49	150	300.	100	0.179E-01	5.46	0.31	LO	0.42	1.39	
302	49	50	100	400.	100	0.172E 00	2.10	0.27	LO	0.68	1.70	
303	49	51	100	400.	100	0.172E 00	2.34	0.30	LO	0.84	2.09	

ANNEX TABLE IX-C-7 (continued)

NODE	GROUND ELEV	FLOW	HGL ELEV	HEAD MTRS	PRESSURE ATM	CK	PRESSURE PCT DROP	CK
1	42.0	-2.87	91.92U	49.92	4.83		18.82	
2	42.0	-0.77	95.19U	53.19	5.15		13.51	
3	42.0	-0.65	95.21U	53.21	5.15		13.49	
4	41.0	-1.40	95.19U	54.19	5.25		13.29	
5	42.0	-1.15	95.29U	53.29	5.16		13.34	
6	41.0	-4.43	95.34U	54.34	5.26		13.05	
7	40.0	-2.89	95.67U	55.67	5.39		12.33	
8	41.0	-1.71	96.11U	55.11	5.33		11.83	
9	41.0	-0.82	95.77U	54.77	5.30		12.37	
10	42.0	-1.22	95.26U	53.26	5.16		13.39	
11	43.0	-3.74	94.45U	51.45	4.98		14.95	
12	46.0	-4.64	92.92U	46.92	4.54		18.39	
13	46.0	-2.71	91.11U	45.11	4.37		21.55	
14	46.0	-2.12	94.60U	48.60	4.70		15.49	
15	46.0	-1.54	94.96U	48.96	4.74		14.85	
16	45.0	-1.56	95.21U	50.21	4.86		14.18	
17	45.0	-1.31	95.48U	50.48	4.89		13.70	
18	43.0	-0.96	95.71U	52.71	5.10		12.87	
19	44.0	-0.82	96.58U	52.58	5.09		11.63	
20	45.0	-0.84	96.77U	51.77	5.01		11.50	
21	45.0	-0.63	97.43U	52.43	5.08		10.38	
22	44.0	-0.96	97.64U	53.64	5.19		9.85	
23	43.0	-1.61	98.08U	55.08	5.33		8.95	
24	43.0	-0.47	98.94U	55.94	5.42		7.53	
25	42.0	-0.44	98.08U	56.08	5.43		8.81	
26	43.0	-0.80	98.52U	55.52	5.37		8.23	
27	42.0	-0.72	98.06U	56.06	5.43		8.84	
28	40.0	-1.68	97.40U	57.40	5.56		9.61	
29	40.0	-1.85	95.69U	55.69	5.39		12.30	
30	40.0	-2.90	95.69U	55.69	5.39		12.31	
31	40.0	-3.13	96.39U	56.39	5.46		11.20	
32	40.0	-2.13	96.53U	56.53	5.47		10.96	
33	41.0	-1.87	98.48U	57.48	5.56		8.03	
34	42.0	-6.07	99.45U	57.45	5.56		6.59	
35	38.0	-3.41	98.02U	60.02	5.81		8.37	
36	45.0	-4.06	100.88U	55.88	5.41		4.47	
37	46.0	-4.48	97.88U	51.88	5.02		9.77	
38	65.0	-4.86	95.72U	30.72	2.97		20.21	
39	50.0	-1.63	94.62U	44.62	4.32		16.61	
40	60.0	0.0	101.95U	41.95	4.06		3.57	
41	103.5	23.17U	103.5C	0.0	0.0	LO	100.00	HI
42	60.0	0.0	106.82U	46.82	4.53		-7.63	
43	44.0	-2.31	94.96U	50.96	4.93		14.36	
44	43.0	-0.77	95.12U	52.12	5.05		13.85	
45	47.0	0.0	97.04U	50.04	4.84		11.44	
46	75.0	-3.34	95.02U	20.02	1.94		29.75	
47	50.0	-5.32	89.79U	39.79	3.85		25.63	
48	36.0	-2.20	91.59U	55.59	5.38		17.65	
49	65.0	-1.01	97.60U	3[illegible]0	3.16		15.32	
50	55.0	-2.10	96.92U	41.92	4.06		13.57	

ANNEX TABLE IX-C-7 (continued)

NODE	GROUND ELEV	FLOW	HGL ELEV	HEAD MTRS	PRESSURE ATM	CK	PCT DROP	CK
51	60.0	-2.34	96.77U	36.77	3.56		15.48	
52	85.0	-7.07	161.02U	76.02	7.36	HI	-310.92	
53	200.0	86.65U	200.00	-0.00	-0.00	LO	100.00	HI
54	75.0	-1.43	160.89U	85.89	8.31	HI	-201.37	
55	46.0	0.0	94.84U	48.64	4.73		15.07	

ANNEX TABLE IX-C-8
COMPUTER PRINTOUT (BAN-WD)
YEAR 2000 MINIMUM FLOW

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BANGUED 2000 MINIMUM FLOW


INPUT AND OUTPUT IN                 LPS
NO OF NODES                          55
NO OF PIPES                          70
MAX NO OF ITERATIONS                 20
PEAKING FACTOR                  0.30000
ALLOW P-DROP FR/STATIC - PCT 30.0
STATIC HGL FOR P-DROP CALC    103.5
MAX UNBAL - LPS                0.05000
MAX ALLOW VEL -MPS               3.000
MIN ALLOW VEL - MPS              0.400
MAX ALLOW HL -  M/1000 M        10.00
MIN ALLOW HL -  M/1000 M         0.30
MAX ALLOW PRESS - ATM            7.000
MIN ALLOW PRESS - ATM            0.700
NO OF HEADS TO BE READ                2
NO OF UNKNOWN CONSUMPTIONS            2
SUM OF FIXED DEMANDS             18.82
BANDWIDTH                             5
ITER  1 UNBAL 8590.82 LPS
ITER  2 UNBAL 4639.14 LPS
ITER  3 UNBAL 2133.71 LPS
ITER  4 UNBAL  981.04 LPS
ITER  5 UNBAL  450.44 LPS
ITER  6 UNBAL  205.64 LPS
ITER  7 UNBAL   91.66 LPS
ITER  8 UNBAL   37.06 LPS
ITER  9 UNBAL   10.52 LPS
ITER 10 UNBAL    1.09 LPS
ITER 11 UNBAL    0.01 LPS

SOLUTION NO. 1 REACHED IN  11 ITERATIONS
       0.0123 GPM UNBALANCE
```

ANNEX TABLE IX-C-8 (continued)

PIPE NO	NODES FROM	NODES TO	DIA MM	L MTRS	H-W C	K-VALUE	FLOW	--VEL-- MPS	CK	--HEADLOSS--- MT	MT/1000	CK
401	11	1	100	290.	100	0.125E 00	0.87	0.11	LO	0.10	0.33	
402	3	2	100	60.	100	0.259E-01	0.12	0.02	LO	0.00	0.01	LO
403	5	3	100	115.	100	0.495E-01	0.24	0.03	LO	0.00	0.03	LO
404	5	10	100	175.	100	0.754E-01	0.11	0.01	LO	0.00	0.01	LO
405	6	5	150	100.	100	0.598E-02	0.54	0.03	LO	0.00	0.02	LO
407	7	6	100	355.	100	0.153E 00	0.26	0.03	LO	0.01	0.03	LO
408	43	11	150	165.	100	0.987E-02	1.43	0.08	LO	0.02	0.12	LO
409	44	43	150	230.	100	0.138E-01	0.65	0.04	LO	0.01	0.03	LO
410	10	44	100	165.	100	0.711E-01	0.25	0.03	LO	0.01	0.03	LO
412	8	7	100	90.	100	0.388E-01	0.64	0.08	LO	0.02	0.19	LO
413	16	43	150	120.	100	0.718E-02	1.17	0.07	LO	0.01	0.08	LO
414	17	16	150	60.	100	0.359E-02	1.79	0.10	LO	0.01	0.18	LO
415	18	44	100	170.	100	0.732E-01	0.53	0.07	LO	0.02	0.13	LO
417	29	7	100	90.	100	0.388E-01	0.12	0.01	LO	0.00	0.01	LO
418	32	29	100	290.	100	0.125E 00	0.48	0.06	LO	0.03	0.11	LO
419	32	31	150	90.	100	0.538E-02	0.99	0.06	LO	0.01	0.06	LO
420	28	32	150	180.	100	0.108E-01	1.84	0.10	LO	0.03	0.18	LO
421	27	28	150	105.	100	0.628E-02	2.12	0.12	LO	0.03	0.24	LO
422	23	25	200	40.	110	0.494E-03	0.31	0.01	LO	0.00	0.00	LO
423	25	27	200	70.	110	0.864E-03	0.93	0.03	LO	0.00	0.01	LO
424	26	25	100	75.	100	0.323E-01	0.70	0.09	LO	0.02	0.22	LO
425	24	23	200	75.	110	0.926E-03	6.87	0.22	LO	0.03	0.44	
426	23	22	150	80.	100	0.478E-02	1.98	0.11	LO	0.02	0.21	LO
427	22	19	100	130.	100	0.560E-01	0.84	0.11	LO	0.04	0.31	
428	19	18	100	150.	100	0.646E-01	0.70	0.09	LO	0.03	0.22	LO
429	20	17	150	110.	100	0.658E-02	2.96	0.17	LO	0.05	0.45	
430	16	55	100	230.	100	0.991E-01	0.35	0.04	LO	0.01	0.06	LO
431	17	15	150	370.	100	0.221E-01	0.95	0.05	LO	0.02	0.05	LO
432	15	14	100	65.	100	0.280E-01	0.68	0.09	LO	0.01	0.21	LO
433	14	13	100	310.	100	0.134E 00	0.67	0.09	LO	0.06	0.21	LO
434	12	13	150	640.	100	0.383E-01	1.38	0.08	LO	0.07	0.11	LO
435	45	38	150	320.	100	0.191E-01	1.69	0.10	LO	0.05	0.16	LO
436	37	45	150	205.	100	0.123E-01	1.69	0.10	LO	0.03	0.16	LO
437	37	29	150	160.	100	0.957E-02	2.24	0.13	LO	0.04	0.27	LO
438	21	20	100	75.	100	0.323E-01	0.87	0.11	LO	0.03	0.33	
439	22	21	150	140.	100	0.837E-02	0.98	0.06	LO	0.01	0.06	LO
440	36	24	200	130.	110	0.161E-02	7.91	0.25	LO	0.07	0.57	
441	33	27	150	160.	100	0.957E-02	1.32	0.07	LO	0.02	0.10	LO
442	34	33	150	290.	100	0.173E-01	1.51	0.09	LO	0.04	0.13	LO
443	34	35	150	420.	100	0.251E-01	1.52	0.09	LO	0.05	0.13	LO
448	52	42	200	4950.	110	0.611E-01	40.38	1.29		57.61	11.64	HI
449	52	42	200	4950.	110	0.611E-01	40.38	1.29		57.61	11.64	HI
450	53	52	200	2940.	110	0.363E-01	41.11	1.31		35.37	12.03	HI
451	53	52	200	2940.	110	0.363E-01	41.11	1.31		35.37	12.03	HI
101	4	2	100	100.	100	0.431E-01	0.01	0.00	LO	0.00	0.00	LO
102	6	4	100	180.	100	0.776E-01	0.25	0.03	LO	0.01	0.03	LO
103	9	6	150	170.	100	0.102E-01	1.29	0.07	LO	0.02	0.10	LO
104	9	10	150	95.	100	0.563E-02	1.94	0.11	LO	0.02	0.20	LO
105	10	11	150	220.	100	0.132E-01	1.58	0.09	LO	0.03	0.14	LO
106	11	12	150	460.	100	0.275E-01	1.50	0.08	LO	0.06	0.13	LO

ANNEX TABLE IX-C-8 (continued)

PIPE NO	NODES FROM	-TO	DIA MM	L MTRS	H-W C	K-VALUE	FLOW	--VEL-- MPS	--CK	--HEADLOSS--- MT	MT/1000	CK
107	8	9	200	110.	110	0.136E-02	3.37	0.11	LO	0.01	0.12	LO
108	23	8	200	410.	110	0.506E-02	4.30	0.14	LO	0.08	0.18	LO
109	29	30	100	110.	100	0.474E-01	0.04	0.01	LO	0.00	0.00	LO
110	31	30	100	270.	100	0.116E 00	0.45	0.06	LO	0.03	0.10	LO
111	26	32	100	150.	100	0.645E-01	0.13	0.02	LO	0.00	0.01	LO
112	24	26	100	40.	100	0.172E-01	0.97	0.12	LO	0.02	0.41	
113	55	14	100	150.	100	0.645E-01	0.35	0.04	LO	0.01	0.06	LO
114	36	27	200	530.	110	0.654E-02	4.69	0.15	LO	0.11	0.22	LO
115	36	34	200	330.	110	0.407E-02	4.07	0.13	LO	0.05	0.17	LO
116	38	39	100	1040.	100	0.448E 00	0.28	0.04	LO	0.04	0.04	LO
117	42	41	300	605.	110	0.104E-02	80.75	1.14		3.53	5.83	
118	40	36	300	120.	110	0.206E-03	17.37	0.25	LO	0.04	0.34	
119	41	40	300	175.	110	0.300E-03	17.37	0.25	LO	0.06	0.34	
201	38	46	150	1250.	100	0.748E-01	0.57	0.03	LO	0.03	0.02	LO
202	13	47	150	1000.	100	0.598E-01	0.91	0.05	LO	0.05	0.05	LO
203	1	48	150	1300.	100	0.777E-01	0.38	0.02	LO	0.01	0.01	LO
204	52	54	150	1100.	100	0.658E-01	0.25	0.01	LO	0.00	0.00	LO
301	35	49	150	300.	100	0.179E-01	0.94	0.05	LO	0.02	0.05	LO
302	49	50	100	400.	100	0.172E 00	0.36	0.05	LO	0.03	0.06	LO
303	49	51	100	400.	100	0.172E 00	0.40	0.05	LO	0.03	0.08	LO

NODE	GROUND ELEV	FLOW	HGL ELEV	HEAD MTRS	PRESSURE ATM	CK	PRESSURE PCT DROP	CK
1	42.0	-0.49	103.06U	61.06	5.91		0.72	
2	42.0	-0.13	103.18U	61.18	5.92		0.52	
3	42.0	-0.11	103.18U	61.18	5.92		0.51	
4	41.0	-0.24	103.18U	62.18	6.02		0.51	
5	42.0	-0.20	103.19U	61.19	5.92		0.51	
6	41.0	-0.76	103.19U	62.19	6.02		0.50	
7	40.0	-0.49	103.20U	63.20	6.12		0.47	
8	41.0	-0.29	103.22U	62.22	6.02		0.45	
9	41.0	-0.14	103.20U	62.20	6.02		0.47	
10	42.0	-0.21	103.19U	61.19	5.92		0.51	
11	43.0	-0.64	103.15U	60.15	5.82		0.57	
12	46.0	-0.79	103.10U	57.10	5.53		0.70	
13	46.0	-0.46	103.03U	57.03	5.52		0.92	
14	46.0	-0.36	103.16U	57.16	5.53		0.59	
15	46.0	-0.26	103.17U	57.17	5.53		0.57	
16	45.0	-0.27	103.18U	58.18	5.63		0.54	
17	45.0	-0.22	103.19U	58.19	5.63		0.52	
18	43.0	-0.16	103.20U	60.20	5.83		0.49	
19	44.0	-0.14	103.24U	59.24	5.73		0.44	
20	45.0	-0.14	103.24U	58.24	5.64		0.44	
21	45.0	-0.11	103.27U	58.27	5.64		0.40	
22	44.0	-0.16	103.28U	59.28	5.74		0.38	
23	43.0	-0.28	103.29U	60.29	5.84		0.34	
24	43.0	-0.08	103.33U	60.33	5.84		0.29	
25	42.0	-0.07	103.29U	61.29	5.93		0.34	
26	43.0	-0.14	103.31U	60.31	5.84		0.31	
27	42.0	-0.12	103.29U	61.29	5.93		0.34	
28	40.0	-0.29	103.27U	63.27	6.12		0.37	
29	40.0	-0.32	103.20U	63.20	6.12		0.47	
30	40.0	-0.50	103.20U	63.20	6.12		0.47	
31	40.0	-0.54	103.23U	63.23	6.12		0.43	
32	40.0	-0.37	103.23U	63.23	6.12		0.42	
33	41.0	-0.32	103.31U	62.31	6.03		0.31	
34	42.0	-1.04	103.35U	61.35	5.94		0.25	
35	38.0	-0.58	103.29U	65.29	6.32		0.32	
36	45.0	-0.70	103.40U	58.40	5.65		0.17	
37	46.0	-0.77	103.29U	57.29	5.55		0.37	
38	65.0	-0.82	103.20U	38.20	3.70		0.77	
39	50.0	-0.28	103.16U	53.16	5.15		0.63	
40	60.0	0.0	103.44U	43.44	4.21		0.14	
41	103.5	-63.39U	103.50	0.0	0.0	LO	100.00	HI
42	60.0	0.0	107.03U	47.03	4.55		-8.11	
43	44.0	-0.40	103.17U	59.17	5.73		0.55	
44	43.0	-0.13	103.18U	60.18	5.83		0.53	
45	47.0	0.0	103.25U	56.25	5.45		0.44	
46	75.0	-0.57	103.18U	28.18	2.73		1.14	
47	50.0	-0.91	102.98U	52.98	5.13		0.98	
48	36.0	-0.38	103.05U	67.05	6.49		0.67	
49	65.0	-0.17	103.27U	38.27	3.71		0.59	
50	55.0	-0.26	103.25U	48.25	4.67		0.52	

ANNEX TABLE IX-C-8 (continued)

NODE	GROUND ELEV	FLOW	HGL ELEV	HEAD MTRS	PRESSURE ATM	CK	PCT DROP	CK
51	60.0	-0.40	103.24U	43.24	4.19		0.59	
52	85.0	-1.21	164.63U	79.63	7.71	HI	-330.45	
53	200.0	82.21U	200.00	-0.00	-0.00	LO	100.00	HI
54	75.0	-0.25	164.63U	89.63	8.68	HI	-214.48	
55	46.0	0.0	103.17U	57.17	5.53		0.58	

CHAPTER X FINANCIAL FEASIBILITY ANALYSIS

A. GENERAL

The financial feasibility analysis herein establishes a detailed set of guidelines that the water district management may use in making crucial decisions during the next few years. The technical aspects and project cost of the recommended plan have been presented in Chapter IX. Its economic justification follows in Chapter XI. In this chapter, a plan is developed to indicate how and when 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. Capital funds for the recommended plan will be derived by borrowing from international lending agencies and LWUA. The water rates that have been developed appear to be within the ability-to-pay of the average householder in the water district.

The financial analyses includes only those revenues and disbursements for the proposed construction program from 1978 to 1990 (Immediate Improvements, Phase I-A and Phase I-B). All revenues and disbursements shown between 1990 and 2000 are those directly attributable to continued service and expenses occurring from facilities constructed between 1978 and 1990.

B. THE EXISTING SYSTEM

Personnel

Prior to the formation of a water district, the waterworks system of Bangued was managed and operated by the municipal government. As of July 1976, the BAN-WD consisted of 11 personnel. Recent developments included the expansion of its present staff and the adoption of LWUA guidelines in the area of personnel management.

Water Rates

The present system has a total of 868 flat-rate connections. As of October 1976, the water rates were as follows:

a) ₱ 4.00 per month for the Bangued town proper.
b) ₱ 8.00 per month for commercial establishments in Bangued.
c) ₱10.00 per month for Peñarrubia (residential and commercial).

Financial Statements

BAN-WD relies solely on its collections from water sales to keep the system operating. Average monthly collection is approximately ₱3,500. From the available financial statements, it appears that income exceeds operating expenses only by a small margin and will result in deficit if allowance were to be made for depreciation.

Historic financial records have not been based on organized basic accounting systems. Therefore, data on the past finances of the present system are inadequate to form sound basis for future projections. It is therefore necessary to make certain assumptions for the financial feasibility analysis. These are discussed later in this chapter. Validity of these assumptions will be tested as the project is implemented.

C. DEVELOPMENT COSTS

The cost estimates of the facilities needed to improve and expand water services of the water district over the development planning period are presented in Chapter IX. Cost estimates of the facilities are based on the projected July 1978 prices.

Project Costs

Project costs of facilities recommended for implementation in Phase I are summarized on an annual basis in Annex Table X-C-1. Engineering services for design and construction supervision are broken down. It has been assumed that 70 percent of the engineering services applies to surveys and design and 30 percent to construction supervision. Design costs are shown in the year preceding construction. Contingencies (15/10 percent) are distributed uniformly during the construction period. Foreign exchange component of total project cost includes cost of direct and indirect import items, as well as a portion of the engineering costs.

Escalation of Costs

To account for the effects of inflation, capital cost estimates are escalated. This has been done year by year on an item-by-item basis using escalation factors computed from assumed inflationary trends and applied to the basic current cost data as shown in Annex Table X-C-2. The escalation factors used are based on an average annual rate of inflation of 10 percent per year from 1978 through 1980, 8 percent from 1981 to 1985 and 6 percent per year thereafter. On the other hand, annual operation and maintenance costs and family income are escalated at a rate of 8 percent all throughout the 23-year study period. These escalation factors have been assumed to apply equally to the local and foreign exchange costs.

D. OPERATING AND MAINTENANCE COSTS

This cost category covers cash expenses required to keep the system operating and adequately maintained. It assures the continued maintenance of the water district's revenue-producing capacity and protection of its investment. Included in this cost category are: personnel, power, chemicals, maintenance, rental, and other miscellaneous expenses which are necessary to run the overall water system. Most items increase in accordance with the quantity of water produced; the number of customers served; and the extent to which the physical plant will be operated and maintained.

The operating costs of the existing and future systems are presented in Chapter IX.

E. FINANCING POLICIES COVERING LOCAL WATER DISTRICT DEVELOPMENT

The following are the major potential sources of funds which can be utilized by the BAN-WD:

Operating Source

To the extent that revenues from the operations of the local water district exceed annual cash requirements for all other purposes, funds can be devoted to financing development costs. As a practical matter, it is highly desirable to finance a significant proportion of development costs in this manner in order to reduce the amount that must be borrowed and the associated debt service costs.

Non-Operating Sources

Non-operating sources of funds for development include 3 basic groups:

1. Loans - funds may be borrowed by the water district for development. One of LWUA's primary functions is lending funds for development to water districts. From the water district's point of view, LWUA is the primary, if not the only realistic source of funds. LWUA borrows both foreign currencies and pesos at varying terms and relends needed funds to water districts according to the composite terms needed to support the blend of debt service terms LWUA itself must meet. At present, LWUA's terms include:

	Immediate Improvements Loan	Phase I-A and I-B Loan
Interest -	9 percent per annum to be computed at $\frac{3}{4}$ percent per month. Interest due on the local component is paid annually. Interest on foreign exchange is capitalized during construction.	9 percent per annum to be computed monthly at $\frac{3}{4}$ percent per month from the year following the date of disbursement.

	Immediate Improvements Loan	Phase I-A and I-B Loan
	Total loan outstanding at the end of construction period earns another full year interest before repayment.	
Duration -	30-year loan, disbursement assumed made at mid-year, thus will earn interest for 6 months.	30-year loan from the date of initial disbursement.
Principal -	amortized equally for 30 years to start one year after construction.	No principal payments due during construction periods (Construction periods of Stage I- Phases A and B are explained in Chapter IX). Principal repayment period is 30 years less the duration of the disbursement period.

2. Charges and Assessments - consist of payments made by new customers and benefiting property owners for the costs of specific portions of the facilities being developed. Typically, such charges are made for the costs of new construction and water meters and for all or a portion of the costs of new distribution system extensions. LWUA policy requires new customers to pay for connections and water meters, but currently does not include an assessment for distribution system costs. These sources are referred to as "contributions in aid of construction" in accounting terminology and have the effect of reducing the amounts to be borrowed. Since many new customers will not be in a position to pay connection fees (or benefit assessment charges) in cash, it will be necessary to provide financing assistance. Present practice is to allow such payments to be made at a flat monthly rate of ₱5.00 over a period of 10 years.
3. Grants or Credits - LWUA has access to loan funds on concessionary terms and is thus able to relend funds at rates that are below market rates. This in itself is a 'credit' available to the local water district borrower. In some countries, the national government makes outright grants to local water districts in recognition of the overall national benefit of having safe and reliable water systems. Another approach is for the government to advance a portion of the funds needed during the early years of development at little or no interest to assist the local utility in building its

financial capacity. This is another form of 'credit' as referred to above. Later, as the revenue base expands and development expenditures decline, the local utility funds such advances as permitted by its cash position. At the present time, however, the local water district is expected to undertake its development programs with no equity participation by government or assistance other than the LWUA loans.

Reserve Requirements

Since reserve requirements are tied directly to obtaining development loans from LWUA, they are considered as funds required to support capital development. After total revenue requirements are determined, LWUA guidelines suggest that 10 percent be set aside for reserve funds. For purposes of this study, a lower percentage will be used, starting at 3 percent progressively increasing to 10 percent.

F. FUNDS FOR CAPITAL DEVELOPMENT

Once the basic data requirements are met and the financing policies outlined, funds required to cover development costs are then determined. The most important document in this regard is the breakdown of project costs as escalated and shown in Annex Table X-C-2.

Depreciable Assets/Depreciation Expenses

Capital assets acquired each year become subject to depreciation in their first full year of service. Thus a pipeline completed in 1978 becomes "depreciable" in 1979. If it has a 50-year life, depreciation continues for 50 years and it is assumed to be retired in the 51st year. The cost of large facilities that require several years to construct is carried as "work-in-process" until completed.

Annex Table X-F-1 shows the water district's assets and depreciable value forecasts, the initial purpose of which is to show the appropriate "depreciable" values for use in calculating replacement costs and annual depreciation expenses. At the same time, year-end book values of assets are shown as well as the value of work-in-process.

Based on the schedule of assets, annual depreciation expenses were calculated and are shown in Annex Table X-F-2.

Revolving Fund for Connections

To assist new customers in financing service connection charges, it is necessary to provide working capital for a revolving fund. It is proposed that LWUA's present policy which provides for the costs to be payable at ₱5.00/month over a 10-year period be increased to ₱6.83 by 1978 to cover the increased unit price of meters. Net inflow funds will be required over a period of 10 years to build sufficient income to support the annual costs of connections. At some future point, income exceeds annual expenditures and the revolving fund can be used to refund the earlier advances of working capital.

Annex Table X-F-3 indicates the working capital requirements. In this table, the two key assumptions are:

1. The monthly installment payments are based on actual costs of constructing service connections and meters; thus, the monthly payments by customers connected to the system in 1981 would be greater than those who would be connected to the system in 1978 to account for the escalation of construction costs.
2. Sixty (60) percent of all new customers would utilize the installment method of financing connection charges.

Revenue Unit Forecast

The present LWUA rate policy incorporates the use of "revenue units" (RU) in determining the basic cost per cubic meter of water to domestic consumers. Commercial and industrial customers are charged twice the unit price for domestic use and wholesale water distributors are charged thrice the basic price. As defined, a "revenue unit" is an arbitrary unit of measure into which discharges from pipes of various sizes are reduced to a 3/8-inch connection by the use of conversion factors.

Thus, the discharge of a 3/8-inch connection (actually a ½-inch connection, but regulated by a water meter to give the discharge of a 3/8-inch connection) is multiplied by 1.0; that of a ½-inch by 2.5; that of a ¾-inch by 4; that of a 1-inch by 8; and so forth, to get the total RUs delivered.

Two charges are levied on metered connections - the service charge and the commodity charge. The service charge is the fixed charge which covers the first 10 cum of water. It varies according to the size of the connection. The commodity charge is payment for water consumed after the first 10 cum. The unit price is uniform for every size and type of connection.

Annex Tables X-F-4a and X-F-4b give the revenue unit forecast.

G. ANALYSIS OF WATER RATES

Ability-To-Pay Issue

Presidential Decree No. 198 stipulates that water districts must be financially self-sufficient. In the past, most water systems have not been able to generate sufficient revenues to cover even the operation and maintanance expenses due to various factors including poor pricing schemes, defective collection system and inadequate consumer promotion. The major reason for insufficient revenues, however, is that certain consumers being served by the water district have such low incomes and hence, are not in a financial position to pay the full costs of the system. Therefore, before a water system is improved and expanded, the ability-to-pay of the population targeted to be served, must be ascertained first.

Since water districts are not expected to be extended government subsidy, the analysis of the factors affecting ability-to-pay has been significantly simplified. The factors that affect ability-to-pay are the annual income of families covered by the water district and the percentage of the their income allocated to water supply.

In March 1975, an informal survey was conducted among Water District General Managers to help gather data needed for the ability-to-pay studies. Questionnaires were distributed to 15 water districts covering provincial areas that differed in size, location and economic conditions.

The answers given by the general managers of the 15 water districts are summarized as follows:

1) Though 10 of the water districts were revenue-producing prior to the change in management of the water district, 13 imposed increased water rates upon takeover.
2) Water consumers generally accepted the increase after some explanations justifying it. Only five received formal complaints about the increased rates while eight received formal complaints about the poor quality of water supply.
3) Ten had difficulty in the collection of water bills primarily due to dissatisfaction of consumers to the water service.
4) Assuming that capital and service improvements were made, the general managers indicated they could increase their rates by as low as 25 percent and as high as 447 percent for the average and below average households.

A formal survey was conducted in April and May, 1975 in the city of Lipa and the Municipality of Tanauan. These pilot areas were selected because (a) they are at present experiencing water supply problems, (b) the income level of their families is similar to that of the national income figure, and (c) they are near Manila, only about 2 hours away by bus.

The survey covered 556 families, classified into 4 income groups. Approximately 28 percent came from the low-income class (below ₱220/month); 55 percent from the middle-income (₱751-₱1,500); and 5 percent from the high-income group (above ₱1,500).

The table below presents the highlights and pertinent findings of the survey:

ESTIMATED ABILITY-TO-PAY BY INCOME GROUPING

					Weighted Average
Income Group % Distribution	₱220 28%	₱221-750 55%	₱751-1,500 12%	₱1,500 5%	
Probable Ability-to-Pay on Basis of Improved Service	₱13.50	₱24.50	₱37.00	₱67.50	₱25.00/mo
Estimated Average Income	₱220	₱660	₱1,000	₱2,700	₱680/household
Ability-to-Pay Divided by Average Income	6.1%	3.7%	3.7%	2.5%	3.7%

The foregoing table indicates that the low-income group may be able to pay a maximum of ₱13.50 a month for water (about 6.1 percent of their average income). In the extreme end, the high-income group may be able to pay a maximum of ₱67.50 a month for water (only 2.5 percent of their average income). This disparity in the percentage of income allocated to water by the 2 income groups may well be the best argument of those advocating a socialized price structure.

The probable maximum ability-to-pay of the pilot area average household is about ₱25.00 per month.[1]

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[1] This figure includes appropriate allowances for the respondents understating their income or willingness to pay and the increase in amount they are willing to pay as a result of improved services.

Family Income

In the Survey of Households Bulletin Series No. 34, published July 1973 by the NCSO, Manila, (page 3, Table 5), the following data are given:

	Total Families	Total Urban	Manila and Suburbs	Other Urban Areas	Rural
Median Family Annual Income, Pesos	₱2,454	₱3,972	₱5,202	₱3,650	₱1,954
Size of Sample, Families	6,347	1,913	525	1,388	4,434

The above data are for the 12-month period May 1970 to April 1971, more or less. The figure for "other urban areas", ₱3,650 median family annual income, may approximate, or may be a little less, than the median family income at the areas served with piped water. As the figures cited above show, in general, people in urban areas tend to be financially better off than people in rural areas. The term "urban areas" includes all urban areas in the country, in general, most urban area of the city or municipality. The inhabitants of the central urban area are expected to be somewhat wealthier than the other areas of the city or municipality.

By July 1976, the annual income for "other urban areas" cited above, escalated at 10 percent per year, would be about ₱6,260/year.

The report, "The Filipino Family, Community, and Nation" by Emma Porio, Frank Lynch and Mary R. Hollnsteiner published by the Institute of Philippine Culture of Ateneo de Manila University in April 1975, cites in Table A9, page 99 the results of a survey in April 1974. The families surveyed were distributed among 15 urban areas, and included 373 families in Metro Manila. Excluding the families in Metro Manila, mean monthly income of the remaining 1,599 families was ₱572, or ₱6,864 per year. Escalating this income at an annual rate of 10 percent, by 1 July 1976, it would be an income of about ₱8,640 per year. These 14 urban areas are among the more urbanized in the country. They included, for instance, only 3 municipalities, the other eleven being classified as cities. The median population of the 14 urban areas in the 1970 census was about 70,000.

Based on these data, the mean family income of the people residing in the water service areas of the communities whose water systems are proposed to be improved might be, by 1 July 1976, somewhere between the

₱6,260 per year (developed from the 1970/71 data of the NCSO) and the ₱8,640 per year (developed from the data of Porio, Lynch and Hollnsteiner). For lack of other data, the average water-using family may have an income of about ₱7,900 during 1976 (or ₱660 per month, which is close to the Lipa household survey). This is equivalent to an annual income of $1,000 for a family of six or seven.

Initial Rate Determination

Several trials were made to come up with "revenue unit" (RU) prices that can be used for a period of several years. It is good practice for the water district to adjust prices every 3 years or so, instead of annually.

Based on the trials made, the water rates established at 3-year interval are as follows:

Period	Water Rate (₱/RU)
1978-1980	₱0.70
1981-1983	1.20
1984-1986	1.60
1987-1989	1.80
1990-1992*	1.90
1993-1995*	2.10
1996-2000*	2.20

The first step of ₱0.70/RU was selected as an intermediate rate, in anticipation of the second step (₱1.20/RU) which is indicative of the required cost to make the system financially viable. The rate of ₱1.20/RU in 1982 cost levels is equivalent to ₱0.82 in 1978 prices (based on 10 percent discount rate). Likewise ₱1.60/RU in 1985 is equivalent to ₱0.82 in 1978 prices.

Feasibility of Charges

The question of feasibility is a matter of analyzing whether or not the customers of the water district are able to pay the required charges both now and in the future in order to obtain safe and reliable water services. Inasmuch as the proposed water rates represent the "mean", determination has been made for that group of households whose income (₱700/mo) also represents the "mean". Probable use of

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*These rates only cover expenses of debt service and operation and maintenance costs incurred for facilities constructed before 1990. Water rates from 1990-2000 would be higher if the BAN-WD continued to construct additional facilities from 1990 to 2000.

water by this group was calculated at 24 cum per month.[2] For present purposes, the study covers consumers with ½-inch connections inasmuch as they comprise the bulk of the domestic/government consumers. Working back, the 1979 rate of ₱0.70 per revenue unit will yield a monthly service charge of ₱17.50. The commodity charge for a 24-cum consumption is ₱9.80 (₱0.70 x 14). For newly connected customers who avail of the 10-year installment plan, monthly expenditure for water will increase by ₱6.85 to account for the service connection charge. Since both water and household incomes increase each year, the impact of the installment charge on the expenditure pattern of the household will decline over the 10-year period of payment. The estimated impact of the increased rates and connection charges on household patterns is shown below for the mid-point of each rate block.

	1979	1982	1985	1988	1991	1994	1997
Escalated income of household earning ₱700/mo in 1976 (8% per year)	880	1,110	1,400	1,800	2,220	2,800	3,520
Expenditure for 24-cum water consumption-service charge (first 10 cum)	17.50	30.00	40.00	45.00	47.50	52.50	55.00
Commodity charge (Rate/RU x 14 cum)	9.80	16.80	22.40	25.20	26.60	29.40	30.80
Income allocation to water for existing consumers (%)	3.1	4.2	4.4	3.9	3.3	2.9	2.4
Connection charge for new customers (₱6.83/mo in 1978)	7.51	9.63	12.13	14.45	17.20	20.48	24.39
Income allocation to water for new customers	3.9	5.1	5.3	4.7	4.1	3.7	3.1

Since the mid-point of the period was selected for comparison, it should be noted that the proportions shown would be slightly higher in the year preceding the mid-point and lower in the succeeding year of each rate block.

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[2] Probable use of water by income groups:

Income Grouping	Below Average	Average	Upper Middle	Upper	Weighted Mean
Probable Water Use cum/mo	16	24	32	44	23.7

In the example shown above, the proportions of the household income required for water services (except in 1982 and 1985 which are the crucial years) are considered within the upper range limit of the ability-to-pay studies done in Lipa City where willingness to pay fees for improved services was found to be about 3.7 percent of the household income.

In the final analysis, if any significant improvement is to be achieved in the scope and quality of public water service and if the requirement for commercially viable and financially self-supporting water districts is to be maintained, all groups of water customers will have to pay substantially higher charges for water services than they have paid in the past.

<u>Socialized Water Rates</u>

A policy guideline in the structuring of water rate charges is that they must be reasonable and realistic. Since water is a prime commodity both for the poor and the rich, the socialized rate may be determined such that a greater financial burden is carried by those who can afford (but not to the point that it becomes oppressive to them).

In the preceding sections, specific rates established meet the cash requirements for an improved system, and at the same time, fall within the average consumer's ability-to-pay. Under this scheme, the cost for the first 10 cum consumed is ₱17.50 and the subsequent consumption, ₱0.70/cum. Thus, the monthly rates for the following water consumption will be:

Usage (cum/mo)	Cost/month (₱)*
16	21.70
18	23.10
20	24.50
22	25.90
24	27.30
30	31.50
32	32.90
44	41.30

The estimated impact on the average income household (assumed to have a monthly 1976 income of ₱660) and the below average income household (assumed to have an adjusted monthly 1976 income of ₱300) is as follows:

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* For ½-inch connection, domestic classification.

Income Level	Projected 1979 Monthly Income	Monthly Usage of Water	Cost of Water/mo	Percent of Income Allocated to Water
Below Average	₱380	16 cum	₱21.70	5.7
Average	830	24 cum	27.30	3.3

The preceding table shows that the financial burden to the below average income group is heavy.

A socialized pricing alternative has been developed to relieve the low income groups of the high financial cost of water with the following rate structure:

first 16 cum/mo at	₱0.80/cum
from 17-24 cum/mo at	₱1.70/cum
from 25 or more cum/mo at	₱2.30/cum

The resulting monthly rates for the various water usages will be:

Usage (cum)	Cost/month (₱)
16	12.80
18	16.20
20	19.60
22	23.00
24	26.40
30	40.20
32	44.80
44	72.40

The corresponding impact on the various income levels is as follows:

Income Level	Projected 1979 Monthly Income	Monthly Usage of Water	Cost of Water/mo	Percent of Income Allocated to Water
Below Average	₱ 380	16 cum	₱12.80	3.4
Average	830	24 cum	26.40	3.2
Upper Middle	1,260	32 cum	44.80	3.6
High	2,910	44 cum	72.40	2.5

The preceding table shows that across the income profile of the community, the monthly costs range from 2.5-3.6 percent of household income.

Revenue Forecasts

Estimated future levels of income from water sales are shown in Annex Table X-G-1.

H. FINANCIAL SUMMARY

Several trials have been conducted in developing the forecasts of financial statements of the BAN-WD. These statements are based on the following major assumptions:

1. Reserve Fund: 3 percent of sales for 1978-1990; 6 percent for 1991-1995; and 10 percent for 1996-2000.
2. Uncollectibles: 2 percent of gross revenue requirements for the first year of a new rate application, and 1 percent for the second and third years.
3. Accounts Receivable: equivalent to 3 months of sales.
4. Accounts Payable: equivalent to 2 months of operating expenses.

External Borrowing Required

Annex Table X-H-1 shows a summary of the external borrowing required and the annual debt servicing of the loans. Two separate analyses were made for the immediate improvement loan and the Phases I-A and I-B loans to comply with prevailing LWUA terms.

Borrowing will start in 1978 and continue through 1990. The immediate improvement loan (1978-1981) will amount to ₱4.207 million. The Phase I-A loan will cover the 5-year period 1980-85 inclusive and will amount to ₱9.834 million. The Phase I-B loan will cover the 5-year period 1986-90 inclusive and will be about ₱3.888 million.

The immediate improvement loan of ₱4.207 million consists of ₱3.638 million in escalated capital expenditures (see Table X-C-2) and ₱0.569 capitalized interest. The Phase 1 loans of ₱9.834 million in 1978 and ₱3.888 million in 1986 include escalated capital expenditures (see Table X-C-2) less revenues from the service connection revolving fund (see Table X-F-3).

Projections of Financial Statements

Annex Table X-H-2 shows the net income (loss) on a yearly basis. Net loss is forecasted in 1982 through 1986. Net income cumulative would show positive values in fifteen of the 23-year study period.

Other related data such as water production, water sales, unaccounted-for-water and rate of return based on net fixed asset in operation are also presented in the table.

Cash Flow Statements

The cash flow statement provides an indication of the adequacy of working capital. It is not generally sufficient to cover cash outlays with revenues because of the tendency of cash receipts to lag behind cash outlays. In general, an expanding organization with an active capital development program and increasing level of activities will require similarly increasing quantities of working capital.

Annex Table X-H-3 presents the annual "Projected Sources and Applications of Funds". Potential net decreases are expected in 1982 through 1984, 1986, 1994 and 1998. By 2000, positive net cumulative cash balance will be ₱4.482 million even if "cash at the beginning of 1978" has been assumed equal to zero.

Other Financial Statements

Appendix Table X-H-4 presents the "Projected Balance Sheet" which shows the projected fixed and current assets, liabilities and equity of the water district from 1978 to 2000.

Rate of Return

Discount rate of return on total investments (Annex Table X-H-5) measures the true efficiency of mobilizing investments on the project from a broader perspective. Taken from a different perspective, it measures the effective utilization of total investments employed in the project. It shows what the compounded growth of investment within the project cycle would be based on the interplay of cash outflows and the resulting inflows from such investment.

Net asset salvage value of ₱2.617 million is added to net cash inflow in the year 2000. This is done based on the assumption that the project will terminate in the last projection year. Hence, assets are to be liquidated and all liabilities are to be paid from the proceeds of the assets.

Several trials were made in finding the rate of interest that equated the present value of the cash inflows to the unrecovered investments. In the BAN-WD, the rate of return, with the assumptions made, is estimated to be 7.59 percent.

I. FINANCIAL RECOMMENDATIONS

1. The water district should establish a revolving fund to assist new customers in financing service connection charges.
2. The proposed water rates (for domestic consumers) to effect self-sufficiency are as follows:

Period	Water Rate ₱/RU
1978-1980	₱0.70
1981-1983	1.20
1984-1986	1.60
1987-1989	1.80
1990-1992*	1.90
1993-1995*	2.10
1996-2000*	2.20

It is recommended, however, that in the implementation of these rates, the water district follow the socialized pricing approach which will generate the same amount of income to meet its requirements.

3. The recommended plan for the first construction phase (Phase I-A) of BAN-WD is financially feasible. Borrowing for that period would be ₱9.834 million.

   External borrowing would still be necessary for the Phase I-B period.

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*This rate is recommended to cover expenses incurred by implementing and operating facilities included in immediate improvement program and Phase I only.

ANNEX X-C

DEVELOPMENT COSTS

ANNEX TABLE X-C-1

PROJECTED COST OF RECOMMENDED PROGRAM
BANGUED WATER DISTRICT
(WITHOUT ESCALATION)
(P x 1000)

Item	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
Source Development			16	121	121									258
Distribution Facilities			255	1,874	1,874	–	–	63	186	186	186	186	184	4,994
Internal Network			34	198	198	198	198	218	121	121	12[illegible]	121	121	1,649
Service Connection a) Pipes			14	82	82	82	82	96	82	82	82	82	81	847
Service Connection b) Meters			6	31	31	31	31	37	31	31	31	31	31	322
Fire Hydrants			5	31	31	31	31	36	22	22	22	22	22	275
Laboratory Facilities a) Equipment			20	145	145									310
Laboratory Facilities b) Structure			16	99	98									213
Meter Repair Facilities a) Equipment			5	36	35									76
Meter Repair Facilities b) Structure			4	33	32									69
Plumbing Shop			29	215	215									459
Vehicles				69										69
Feasibility Studies[1]			96											96
Immediate Improvements a) Distribution Facilities 1. Equipment	28													28
2. Structure	1,731													1,731
b) Administration Building 1. Equipment	113													113
2. Structure	459													459
c) Storage Facilities	36													36
d) Service Connections 1. Pipes	214	178	179											571
2. Meters	148	123	124											395
e) Vehicles	76													76
f) Miscellaneous Items	16													16
g) Feasibility Studies	35													35
Sub-Total[2]	2,856	301	803	2,934										13,097
Land	84	–	19	–	–	–								103
Total Project Cost[3]	2,940	301	822	2,934	2,862	342	342	450	442	442	442	442	439	13,200

[1] Computed at approximately 1% of total project cost.
[2] Includes design (first year of each major segment of development), supervision of construction and contingencies spread uniformly during the period of construction.
[3] Does not include interest during construction. For calculated interest see Table X-H-1.

ANNEX TABLE X-C-2

PROJECTED COST OF RECOMMENDED PROGRAM
BANGUED WATER DISTRICT
(ESCALATED)
(P x 1000)

Item		FEC (%)	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
Escalation Factor			1.000	1.100	1.210	1.307	1.412	1.525	1.647	1.779	1.886	1.999	2.119	2.246	2.381	
Source Development		58			19	158	171									348
Distribution Facilities		52			309	2,449	2,646			112	351	372	394	418	438	7,489
Internal Network		44			41	259	280	302	326	388	228	242	256	272	288	2,882
Service Connection	a) Pipes	50			17	107	116	125	135	171	155	164	174	184	193	1,541
	b) Meters	83			7	41	44	47	51	66	58	62	66	70	74	586
Fire Hydrants		59			6	41	44	47	51	64	41	44	47	49	52	486
Laboratory Facilities	a) Equipment	89			24	190	205									419
	b) Structure	33			19	128	138									285
Meter Repair Facilities	a) Equipment	90			6	46	49									101
	b) Structure	6			5	42	45									92
Plumbing Shop		6			35	281	304									620
Vehicles		51				90										90
Feasibility Studies					116											116
Immediate Improvement	a) Distribution Facilities															
	1. Equipment	90	28													28
	2. Structure	53	1,731													1,731
	b) Administration Building															
	1. Equipment	70	113													113
	2. Structure	6	459													459
	c) Storage Facilities	90	36													36
	d) Service Connections															
	1. Pipes	50	214	196	217											627
	2. Meters	83	148	135	150											433
	e) Vehicles	51	76	-												76
	f) Miscellaneous Items	62	16													16
	g) Feasibility Studies	55	35	-												35
Sub-Total			2,856	331	971	3,832	4,042	521	563	801	833	884	937	993	1,045	18,609
Land			84	-	23	-	-	-	-	-	-	-	-	-	-	107
Total Project Cost			[illegible]940	331	994	3,832	4,042	521	563	801	833	884	937	993	1,045	18,716

ANNEX X-F

FUNDS FOR CAPITAL DEVELOPMENT

ANNEX TABLE X-F-1

ASSET AND DEPRECIABLE VALUE FORECAST
BANGUED WATER DISTRICT
(P x 1000)

Item	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
I. WORK-IN-PROCESS																							
Source Development			19	177	348																		
Laboratory Facilities a) Equipment			24	214	419																		
b) Structure			19	147	285																		
Meter Repair Facilities a) Equipment			6	52	101																		
b) Structure			5	47	92																		
Plumbing Shop			35	316	620																		
Total Work-in-Process			108	953	1865																		
II. ASSETS ADDED BY YEAR END																							
Distribution Facilities			309	2449	2646			112	351	372	394	418	438										
Internal Network			41	259	280	302	326	388	228	242	256	272	288										
Service Connections a) Pipes			17	107	116	125	135	171	155	164	174	184	193										
b) Meters			7	41	44	47	51	65	58	62	66	70	74										
Fire Hydrants			6	41	44	47	51	64	41	44	47	49	52										
Vehicles				90																			
Feasibility Studies			116																				
Immediate Improvements a) Distribution Facilities																							
1. Equipment	28																						
2. Structure	1731																						
b) Administration Building																							
1. Equipment	113																						
2. Structure	459																						
c) Storage Facilities	36																						
d) Service Connections																							
1. Pipes	214	196	217																				
2. Meters	148	135	150																				
e) Vehicles	76																						
f) Miscellaneous Items	16																						
g) Feasibility Studies	35																						
Replacements a) Meters																	370	392	419	111	118	125	132
b) Laboratory Facilities - Equipment																					1100		
c) Meter Repair Facilities - Equipment																					269		
d) Distribution Facilities - Equipment																	78						
e) Administrative and Miscellaneous Facilities - Equipment																	316						
f) Vehicles									134			150					213			240			
g) Miscellaneous Items																	45						
Total Assets Added By Year-End	2856	331	863	2987	3130	521	563	801	967	884	937	1143	1045				1022	392	419	351	1487	125	132
III. DEPRECIABLE VALUES																							
A. 50 Years Service Life																							
Existing Facilities	2041	2041	2041	2041	2041	2041	2041	2041	2041	2041	2041	2041	2041	2041	2041	2041	2041	2041	2041	2041	2041	2041	2041
Source Development	-	-	-	-	-	348	348	348	348	348	348	348	348	348	348	348	348	348	348	348	348	348	348
Storage Facilities	-	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	35	36
Distribution Facilities - Structure	-	1731	1731	2020	4459	7135	7135	[illegible]	7247	7598	7970	8364	8782	9220	9220	9220	9220	9220	9220	9220	9220	9220	9220
Internal Network	-	-	-	41	300	580	882	1208	1596	1824	2066	2322	2594	2882	2882	2882	2832	2882	2882	2882	2882	2882	2882
Fire Hydrants	-	-	-	6	47	91	138	189	253	294	338	395	434	486	486	486	486	486	486	486	486	486	486

ANNEX TABLE X-F-1 (CONTINUED)

ASSET AND DEPRECIABLE VALUE FORECAST
BANGUED WATER DISTRICT
(P x 1000)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Service Connection - Pipes	-	214	410	644	751	867	992	1127	1298	1453	1617	1791	1975	2168	2168	2168	2168	2168	2168	2168	2168	2168	2168
Laboratory Facilities - Structure	-	-	-	-	-	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285	285
Meter Repair Facilities - Structure	-	-	-	-	-	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92
Plumbing Shop	-	-	-	-	-	620	620	620	620	620	620	620	620	620	620	620	620	620	620	620	620	620	620
Administration Building - Structure	-	459	459	459	459	459	459	459	459	459	459	459	459	459	459	459	459	459	459	459	459	459	459
Total 50 Years Service Life	2041	4481	4677	5267	8163	12554	1,028	13540	14275	15050	15872	16743	17666	18637	18637	18637	18637	18637	18637	18637	18637	18637	18637
B. 30 Years Service Life																							
Feasibility Studies	-	35	35	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151
Total 30 Years Service Life	-	35	35	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151
C. 15 Years Service Life																							
Meters	-	148	283	440	481	525	572	623	689	747	809	875	945	1019	1019	1019	871	1106	1341	1719	1786	1857	1931
Laboratory Facilities - Equipment	-	-	-	-	-	419	419	419	419	419	419	419	419	419	419	419	419	419	419	419	-	1100	1100
Meter Repair Facilities - Equipment	-	-	-	-	-	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	-	269	269
Distribution Facilities - Equipment	-	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	-	78	78	78	78	78	78
Administration Building - Equipment	-	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113	-	316	316	316	316	316	316
Miscellaneous Items	-	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	-	45	45	45	45	45	45
Total 15 Years Service Life	-	305	440	597	638	1202	1249	1300	1366	1424	1486	1552	1622	1696	1696	1696	1391	2065	2300	2678	2225	3665	3739
D. 7 Years Service Life																							
Vehicles	-	76	76	76	166	166	166	166	90	224	224	134	284	284	284	284	150	363	363	213	453	453	453
Total 7 Years Service Life	-	76	76	76	166	166	166	166	90	224	224	134	284	284	284	284	150	363	363	213	453	453	453
TOTAL DEPRECIABLE VALUES	2041	4897	5228	6091	9078	14073	14594	15157	15882	16849	17733	18580	19723	20768	20768	20768	20329	21216	21451	21679	21466	22906	22980
BOOK VALUE OF ASSETS OTHER THAN LAND	4897	5228	6199	10031	14073	14594	15157	15956	16849	17733	18670	19723	20768	20768	20768	20768	21315	21608	21870	22030	22953	23031	23112
LAND	84	84	107	107	107	107	107	107	107	107	107	107	107	107	107	107	107	107	107	107	107	107	107
TOTAL BOOK VALUE OF ALL CAPITAL ASSETS	4981	5312	6306	10138	14180	14701	15264	16065	16956	17840	18777	19830	20875	20875	20875	20875	21458	21715	21977	22137	23060	23138	23219

ANNEX TABLE X-F-2

SCHEDULE OF DEPRECIATION EXPENSES
BANGUED WATER DISTRICT
(P x 1000)

Year	Service Life Category 50 Years	30 Years	15 Years	7 Years	Total Annual Depreciation Expenses	Accumulated Depreciation Prior Year	Book Value of Assets Retired During The Year 50 Years	30 Years	15 Years	7 Years	Total	Net Accumulated Depreciation Year End
1976												
1977												
1978	41	-	-	-	41	933						974
1979	90	1	20	11	122	974						1,096
1980	94	1	29	11	135	1,096						1,231
1981	105	5	40	11	161	1,231						1,392
1982	162	5	43	24	234	1,392						1,626
1983	251	5	80	24	360	1,626						1,986
1984	261	5	83	24	373	1,986						2,359
1985	271	5	87	24	387	2,359						2,746
1986	286	5	91	13	395	2,746				76	76	3,065
1987	301	5	95	32	433	3,065						3,498
1988	317	5	99	32	453	3,498						3,951
1989	335	5	103	19	462	3,951				90	90	4,323
1990	353	5	108	41	507	4,323						4,830
1991	373	5	113	41	528	4,830						5,358
1992	373	5	113	41	532	5,358						5,890
1993	373	5	113	41	532	5,890						6,422
1994	373	5	93	21	492	6,422			305	134	518	6,475
1995	373	5	138	52	568	6,475			135		135	6,908
1996	373	5	153	52	583	6,908			157		157	7,334
1997	373	5	179	30	587	7,334			41	150	191	7,730
1998	373	5	148	65	591	7,730			564		564	7,757
1999	373	5	244	65	687	7,757			47		47	8,397
2000	373	5	249	65	692	8,397			51		51	9,038

ANNEX TABLE X-F-3

WORKING CAPITAL REQUIREMENTS
FOR REVOLVING FUND FOR NEW CONNECTIONS
BANGUED WATER DISTRICT

						₱ x 1000							
								Cash Receipts					
Year	Number of New Connections	Number of Installment Plan Added	Number of Installment Plan Paid	Total Paying Monthly Installment (Cumulative)	Monthly Installment Plan (Escalated)	Increment Added 4/	Increment Deducted 5/	Lump Sum Payments 6/ (Escalated)	Installment Payments (Cumulative)	Total Payments	Annual Construction Cost 7/	Working Capital Required	Cumulative Capital Requirements
1978	161	97		97	6.83	8		41	4	45	102	57	57
1979	161	97		194	7.51	9		45	13	58	112	54	111
1980	162	97		291	8.26	10		50	22	72	124	52	163
1981	121	73		364	8.92	8		40	31	71	100	29	192
1982	121	73		437	9.63	8		44	39	83	109	26	218
1983	121	73		510	10.40	9		47	48	95	117	22	240
1984	121	73		583	11.23	10		51	57	108	127	19	259
1985	121	73		656	12.13	11		55	68	123	137	14	273
1986	121	73		729	12.86	11		58	79	137	145	8	281
1987	121	73		802	13.63	12		62	90	152	154	2	283
1988	121	73	49	826	14.45	13	4	65	99	164	163	(1)	282
1989	121	73	97	802	15.31	13	9	69	103	172	173	1	283
1990	122	73	97	778	16.23	14	10	73	106	179	183	4	287
1991			85	693	17.20		9		104	104		(104)	183
1992			73	620	18.23		8		96	96		(96)	87
1993			73	547	19.32		8		88	88		(88)	(1)
1994			73	474	20.48		9		79	79		(79)	(80)
1995			73	401	21.71		11		68	68		(68)	(148)
1996			73	328	23.01		11		57	57		(57)	(205)
1997			73	255	24.39		12		45	45		(45)	(250)
1998			73	182	25.85		13		32	32		(32)	(282)
1999			73	109	27.40		13		19	19		(19)	(301)
2000			73	36	29.04		14		5	5		(5)	(306)

4/ Accumulated Installment payments are calculated on the basis of 100 percent incremental additions during previous years and 50 percent of the last year.
5/ Based on the assumption that installment plan will be paid back in ten years.
6/ Assumed to be 40 percent of construction cost.
7/ Amount to be shouldered by the customers which is: 2/3 of pipes + meters.

ANNEX TABLE X-F-4a

STRATIFICATION OF SERVICE CONNECTIONS
BANGUED WATER DISTRICT

Year	Domestic/Institutional 1/2"	Domestic/Institutional 3/4"	Domestic/Institutional 1"	Sub-Total	Commercial/Industrial 1/2"	Commercial/Industrial 3/4"	Commercial/Industrial 1"	Sub-Total	Total Connections
1978	869	37	9	915	93	20	11	124	1,039
1980	1,139	48	12	1,199	122	26	15	163	1,362
1985	1,645	69	17	1,732	177	38	21	236	1,968
1990	2,158	91	23	2,264	232	49	28	309	2,573

TABLE X-F-4b

REVENUE UNIT FORECAST[8]

Year	Domestic/Government 1/2" (2.5)	Domestic/Government 3/4" (4.0)	Domestic/Government 1" (8.0)	Sub-Total	Commercial/Industrial 1/2" (5.0)	Commercial/Industrial 3/4" (8.0)	Commercial/Industrial 1" (16.0)	Sub-Total	Grand Total[9]	Service Charge[10]	Estimated Consumption (cum) Domestic	Estimated Consumption (cum) Commercial	Commodity Charge (RUs) Domestic[11]	Commodity Charge (RUs) Commercial[12]	Total RUs
1978	2,173	148	72	2,393	465	160	176	801	3,194	383,280	156,950	19,710	47,150	9,660	440,090
1979	2,848	192	96	3,136	610	208	240	1,058	4,194	503,280	350,400	44,165	206,520	49,210	759,010
1985	4,113	276	136	4,525	885	304	336	1,525	6,050	726,000	512,825	64,605	304,985	72,570	1,103,555
1990	5,395	364	184	5,943	1,160	392	448	2,000	7,943	953,160	738,760	100,740	467,080	127,320	1,547,560

8/ Computation of revenue units based on LWUA guidelines on structuring water rates.

9/ Grand total of number of connections multiplied by their respective conversion factors for computing revenue units (in RUs).

10/ Multiply grand total by 120 (derived from 10 cum/month, the minimum amount covered by the service charge. 12 months/year) in RUs.

11/ [Domestic consumption - (120 x number of domestic connections)] x use factor. Use factor for domestic/institutional classification is 1.

12/ [Commercial consumption - (120 x number of commercial connections)] x use factor. Use factor for commercial classification is 2.

ANNEX X-G

ANALYSIS OF WATER RATES

ANNEX TABLE X-G-1

REVENUE FORECASTS
BANGUED WATER DISTRICT

Year	Rate/Ru ₱	Estimated Number of R.U.s (Yearly in 1000's)	₱ x 1000 Income from Sales	Bad Debt	Other Income 13/	Total Net Income
1978	0.70	440	308	6	6	308
1979	0.70	600	420	4	8	424
1980	0.70	759	531	5	11	537
1981	1.20	828	994	20	20	994
1982	1.20	897	1,076	11	22	1,087
1983	1.20	966	1,159	12	23	1,170
1984	1.60	1,035	1,656	33	33	1,656
1985	1.60	1,104	1,766	18	35	1,783
1986	1.60	1,193	1,909	19	38	1,928
1987	1.80	1,281	2,306	46	46	2,306
1988	1.80	1,370	2,466	24	49	2,491
1989	1.80	1,459	2,626	26	53	2,653
1990	1.90	1,548	2,941	59	59	2,941
1991	1.90	↓	2,941	29	59	2,971
1992	1.90		2,941	29	59	2,971
1993	2.10		3,251	65	65	3,251
1994	2.10		3,251	33	65	3,283
1995	2.10		3,251	33	65	3,283
1996	2.20		3,406	68	68	3,406
1997	2.20		3,406	34	68	3,440
1998	2.20		3,406	34	68	3,440
1999	2.20	↓	3,406	34	68	3,440
2000	2.20	1,548	3,406	34	68	3,440

13/ Other income (derived from meter replacement charges, contingency fees of new connections, service fees, etc.) is about 2% of sales.

ANNEX X-H

FINANCIAL SUMMARY

ANNEX TABLE X-H-1

DEBT SERVICE SCHEDULE OF TOTAL PROJECT LOAN
BANGUED WATER DISTRICT
(₱ x 1000)

Year	Outstanding Loan End of Year			Capital Repayments			Interest Payments			Total Debt Service
	Immediate Improvement	Phase I-A and I-B	Total	Immediate Improvement	Phase I-A and I-B	Total	Immediate Improvement	Phase I-A and I-B	Total	
1978	3,002	-	3,002	-	-	-	70	-	70	70
1979	3,472	-	3,472	-	-	-	146	-	146	146
1980	4,010	555	4,565	-	-	-	158	-	158	158
1981	4,207	4,316	8,523	-	-	-	164	50	214	214
1982	4,177	8,275	12,452	30	-	30	379	388	767	797
1983	4,144	8,701	12,845	33	-	33	376	745	1,121	1,154
1984	4,108	9,156	13,264	36	-	36	373	783	1,156	1,192
1985	4,069	9,834	13,903	39	-	39	370	824	1,194	1,233
1986	4,026	10,456	14,482	43	74	117	366	885	1,251	1,368
1987	3,979	11,114	15,093	47	74	121	362	941	1,303	1,424
1988	3,928	11,813	15,741	51	74	125	358	1,000	1,358	1,483
1989	3,873	12,523	16,396	55	111	166	354	1,063	1,417	1,583
1990	3,813	13,278	17,091	60	111	171	349	1,127	1,476	1,647
1991	3,747	13,138	16,885	66	140	206	343	1,195	1,538	1,744
1992	3,676	12,924	16,600	71	214	285	338	1,182	1,520	1,805
1993	3,598	12,710	16,308	78	214	292	331	1,163	1,494	1,786
1994	3,513	12,408	15,921	85	302	387	324	1,144	1,468	1,855
1995	3,420	12,106	15,526	93	302	395	316	1,117	1,433	1,828
1996	3,319	11,730	15,049	101	376	477	308	1,090	1,398	1,875
1997	3,209	11,325	14,534	110	405	515	299	1,056	1,355	1,870
1998	3,089	10,920	14,009	120	405	525	289	1,019	1,308	1,833
1999	2,958	10,486	13,444	131	434	565	278	983	1,261	1,826
2000	2,815	9,978	12,793	143	508	651	266	944	1,210	1,861

ANNEX TABLE X-H-2

PROJECTED INCOME STATEMENT
BANGUED WATER DISTRICT
(P x 1000)

		1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Water Production per Year	(1,000 x cum)	.561		1800					2379				
Water Sales per Year	(1,000 x cum)	484		1081					1582				
Unaccounted-for-Water	(%)	69	Increasing to →	40	— Increasing to →				34	— Increasing to →			
Connections - Metered		1039		1362					1968				
Consumption	(lpcd)	72		107					116				
OPERATING REVENUE													
Water Sales		308	420	531	994	1076	1159	1656	1766	1909	2306	2466	2626
Less: Uncollectibles		6	4	5	20	11	12	33	18	19	46	24	26
Other Revenue		6	8	11	20	22	23	33	35	38	46	49	53
Total Revenue		308	424	537	994	1087	1170	1656	1783	1928	2306	2491	2653
OPERATING EXPENSES													
Administration and Personnel		63	87	117	215	232	251	272	292	323	349	377	406
Power and Fuel		13	14	15	17	18	19	21	23	24	26	29	31
Chemicals		2	4	8	10	12	13	14	17	20	23	25	29
Maintenance		11	18	28	39	50	64	79	95	106	117	130	144
Miscellaneous		4	5	6	7	8	10	12	15	17	21	24	29
Depreciation		41	122	135	161	234	360	373	387	395	433	453	462
Total Operating Expenses		134	250	309	449	554	717	771	829	885	969	1038	1101
Operating Income		174	174	228	545	533	453	885	954	1043	1337	1453	1552
Plus: Interest on Reserves		1	2	4	7	11	16	22	29	37	46	56	67
Net Income Before Interest		175	176	232	552	544	469	907	983	1080	1383	1509	1619
Interest On Debt		70	146	158	214	767	1121	1156	1194	1251	1303	1358	[illegible]
Net Income (Loss)		105	30	74	338	(223)	(652)	(249)	(211)	(171)	80	151	202
Cumulative Net Income (Loss)		105	135	209	547	324	(328)	(577)	(788)	(959)	(879)	(728)	(526)
Appropriation to Reserves		9	13	16	30	32	35	50	53	57	69	74	79
Average Net Fixed Assets in Operation		3055	4243	4878	6851	9810	12271	13379	13681	14174	14689	15153	15736
Rate of Return (%)		5.7	4.1	4.7	8.0	5.4	3.7	6.6	7.0	7.4	9.1	9.6	9.9

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Water Production per Year	(1,000 x cum)	3200										[illegible]
Water Sales per Year	(1,000 x cum)	2306										2300
Unaccounted-for-Water	(%)	28	→ Increasing to →									28
Connections - Metered		2573										2573
Consumption	(lpcd)	125										125
OPERATING REVENUE												
Water Sales		2941	2941	2941	3251	3251	3251	3406	3406	3406	3406	3406
Less: Uncollectibles		59	29	29	65	33	33	68	34	34	34	34
Other Revenue		59	59	59	65	65	65	68	68	68	68	68
Total Revenue		2941	2971	2971	3251	3283	3283	3406	3440	3440	3440	3440
OPERATING EXPENSES												
Administration and Personnel		468	505	546	590	637	688	743	802	866	936	1010
Power and Fuel		33	36	38	42	45	48	52	57	61	66	71
Chemicals		33	36	38	42	45	48	52	57	61	66	[illegible]
Maintenance		161	174	188	203	219	237	255	276	298	322	348
Miscellaneous		35	38	41	44	48	51	56	60	65	70	76
Depreciation		507	528	532	532	492	568	583	587	591	687	692
Total Operating Expenses		1237	1317	1383	1453	1486	1640	1741	1839	1942	2147	2268
Operating Income		1704	1654	1588	1798	1797	1643	1665	1601	1498	1293	1172
Plus: Interest on Reserves		79	98	123	149	176	203	241	289	337	385	433
Net Income Before Interest		1783	1752	1711	1947	1973	1846	1906	1890	1835	1678	1605
Interest On Debt		1476	1538	1520	1494	1468	1433	1398	1355	1308	1261	1210
Net Income (Loss)		307	214	191	453	505	413	508	535	527	417	395
Cumulative Net Income (Loss)		(219)	(5)	186	639	1144	1557	2065	2600	3127	3544	3939
Appropriation to Reserves		88	176	176	195	195	195	344	344	344	344	344
Average Net Fixed Assets in Operation		16345	16350	15820	15288	15287	15464	15294	15094	15424	15591	15030
Rate of Return (%)		10.4	10.7	10.0	11.8	11.8	10.6	10.9	10.6	9.7	8.3	7.8

ANNEX TABLE X-5-3

PROJECTED SOURCES AND APPLICATIONS OF FUNDS
BANGUED WATER DISTRICT
(P x 1000)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
SOURCES OF FUNDS												
Net Income Before Interest	175	176	232	552	544	469	907	983	1080	1383	1509	1619
Add: Depreciation	41	122	135	161	234	360	373	387	395	433	453	462
Total Internal Cash Generation	216	298	367	713	778	829	1280	1370	1475	1816	1962	2081
Long-Term Borrowing	3002	470	1093	3958	3959	426	455	678	696	732	773	821
Capital Contributions	45	58	72	71	83	95	108	123	137	152	164	172
Total External Cash Generation	3047	528	1165	4029	4042	521	563	801	833	884	937	993
Total Sources of Funds	3263	826	1532	4742	4820	1350	1843	2171	2303	2700	2899	3074
APPLICATIONS OF FUNDS												
Capital Expenditures	2940	331	994	3832	4042	521	563	801	833	884	937	993
Capitalized Interest	62	139	171	197								
Debt Service: Interest	70	146	158	214	767	1121	1156	1194	1251	1303	1358	1417
Principal					30	33	36	39	117	121	125	166
Sub-total	70	146	158	214	797	1154	1192	1233	1368	1424	1483	1583
Replacements									134			150
Increase in Working Capital	148	39	41	1	54	20	120	(12)	30	137	43	39
Total Applications of Funds	3220	655	1364	4244	4893	1695	1875	2022	2365	2445	2463	2765
INCREASE (DECREASE) IN CASH BALANCE	43	171	168	498	(73)	(345)	(32)	149	(57)	255	436	309
CASH BALANCE BEGINNING OF YEAR		43	214	382	880	807	462	430	579	522	777	1213
CASH BALANCE END OF YEAR	43	214	382	880	807	462	430	579	522	777	1213	1522
DEBT-SERVICE RATIO	3.08	2.04	2.32	3.33	0.98	0.72	1.07	1.11	1.08	1.28	1.32	1.31
RATIO OF INTERNAL CASH GENERATION LESS DEBT-SERVICE TO CAPITAL EXPENDITURE (%)	4.86	32.34	18.0	12.39			15.63	17.10	12.85	44.34	51.12	50.15

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
SOURCES OF FUNDS											
Net Income Before Interest	1783	1752	1711	1947	1973	1846	1906	1890	1835	1678	1605
Add: Depreciation	507	528	532	532	492	568	583	587	591	687	692
Total Internal Cash Generation	2290	2280	2243	2479	2465	2414	2489	2477	2426	2365	2297
Long-Term Borrowing	866										
Capital Contributions	179	104	96	88	79	68	57	45	32	19	5
Total External Cash Generation	1045	104	96	88	79	68	57	45	32	19	5
Total Sources of Funds	3335	2384	2339	2567	2544	2482	2546	2522	2458	2384	2302
APPLICATIONS OF FUNDS											
Capital Expenditures	1045										
Capitalized Interest											
Debt Service: Interest	1476	1538	1520	1494	1468	1433	1398	1355	1308	1261	1210
Principal	171	206	285	292	387	395	477	515	525	565	651
Sub-total	1647	1744	1805	1786	1855	1828	1875	1870	1833	1826	1861
Replacements					1022	392	419	351	1487	125	132
Increase in Working Capital	4	(56)	(9)	58	120	(4)	26	(123)	11	(13)	(14)
Total Applications of Funds	2696	1688	1796	1844	2997	2216	2320	2098	3331	1938	1979
INCREASE (DECREASE) IN CASH BALANCE	639	696	543	723	(453)	266	226	424	(873)	446	323
CASH BALANCE BEGINNING OF YEAR	1522	2161	2857	3400	4123	3670	3936	4162	4586	3713	4159
CASH BALANCE END OF YEAR	2161	2857	3400	4123	3670	3936	4162	4586	3713	4159	4482
DEBT-SERVICE RATIO	1.39	1.31	1.24	1.39	1.33	1.32	1.33	1.32	1.32	1.30	1.23
RATIO OF INTERNAL CASH GENERATION LESS DEBT-SERVICE TO CAPITAL EXPENDITURE (%)	61.53										

ANNEX TABLE X-H-4

PROJECTED BALANCE SHEET
BANGUED WATER DISTRICT
(P x 1000)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
ASSETS																							
Fixed Assets:																							
Gross Value of Fixed Assets	5043	5513	6570	9754	12884	15270	15833	16634	17525	18409	19346	20399	21444	21444	21444	21444	22027	22284	22546	22706	23629	23707	23788
Less: Accumulated Depreciation	974	1096	1231	1392	1626	1986	2359	2746	3065	3493	3951	4323	4830	5355	5890	6422	6475	6908	7334	7730	7757	8397	9038
Net Value of Fixed Assets	4069	4417	5339	8362	11258	13284	13474	13888	14460	14911	15395	16076	16614	16086	15554	15022	15552	15376	15212	14976	15872	15310	14750
Work in Process	-	-	108	953	1865	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Fixed Assets	4069	4417	5447	9315	13123	13284	13474	13888	14460	14911	15395	16076	16614	16086	15554	15022	15552	15376	15212	14976	15872	15310	14750
Current Assets:																							
Cash	43	214	382	880	807	462	430	579	522	777	1213	1522	2161	2857	3400	4123	3670	3936	4162	4586	3713	4159	4482
Accounts Receivable	64	98	133	249	269	290	414	442	477	577	617	657	735	735	735	813	813	813	852	852	852	852	852
Provision for Bad Debts	1	1	1	5	3	3	8	4	5	12	6	6	15	7	7	16	8	8	17	9	9	9	9
Inventories	101	111	125	33	70	76	83	47	51	102	108	116	66	12	13	14	138	147	157	42	69	74	79
Total Current Assets	207	422	639	1157	1143	825	919	1064	1045	1444	1932	2289	2947	3597	4141	4934	4613	4888	5154	5471	4625	5076	5404
Total Assets	4276	4839	6086	10472	14266	14109	14393	14952	15505	16355	17327	18365	19561	19683	19695	19956	20165	20264	20366	20447	20497	20386	20154
EQUITY AND LIABILITIES																							
Current Liabilities:																							
Accounts Payable	16	21	29	48	53	60	66	74	82	89	98	107	122	132	142	154	166	179	193	209	225	243	262
Current Maturities of Long-Term Debt	-	-	-	30	33	36	39	117	121	125	166	171	206	285	292	387	395	477	515	525	565	651	692
Total Current Liabilities	16	21	29	78	86	96	105	191	203	214	264	278	328	417	434	541	561	656	708	734	790	894	954
Long-Term Debt (Less: Current Maturities)	3002	3472	4565	8493	12419	12809	13225	13786	14361	14968	15575	16225	16885	16600	16308	15921	15526	15049	14534	14009	13444	12793	12101
Equity:																							
Government Contribution	1108	1108	1108	1108	1108	1108	1108	1108	1108	1108	1108	1108	1108	1108	1108	1108	1108	1108	1108	1108	1108	1108	1108
Capital Contribution	45	103	175	246	329	424	532	655	792	944	1108	1280	1459	1563	1659	1747	1826	1894	1951	1996	2028	2047	2052
Reserves	9	22	38	68	100	135	185	238	295	364	435	517	605	781	957	1152	1347	1542	1686	2230	2574	2918	3262
Unappropriated Retained Earnings	96	113	171	479	224	(463)	(762)	(1026)	(1254)	(1243)	(1163)	(1343)	(824)	(736)	(771)	(513)	(203)	15	179	370	553	626	677
Total Equity	1258	1346	1492	1901	1761	1204	1063	975	941	1173	1489	1362	2348	2666	2953	3494	4078	4559	5124	5704	6263	6699	7099
Total Equity and Liabilities	4276	4839	6086	10472	14266	14109	14393	14952	15505	16355	17327	18365	19561	19683	19695	19356	20165	20264	20366	20447	20497	20386	20154

ANNEX TABLE X-H-5

RATE OF RETURN ON TOTAL INVESTMENT
(DISCOUNTED CASH FLOW METHOD)
BANGUED WATER DISTRICT
(₱ x 1000)

Year	Debt Service	Net Increase In Cash	Total Cash Inflow	Investments	Net Cash Inflow	1st Trial Present Value:10% Factor	1st Trial Present Value:10% Value	2nd Trial Present Value:5% Factor	2nd Trial Present Value:5% Value
1978	70	43	113	3,002	(2,889)	1.000	(2,889)	1.0	(2,889)
1979	146	171	317	470	(153)	.909	(139)	.952	(146)
1980	158	168	326	1,165	(839)	.826	(693)	.907	(761)
1981	214	498	712	4,029	(3,317)	.751	(2,491)	.864	(2,866)
1982	797	(73)	724	4,042	(3,318)	.683	(2,266)	.823	(2,731)
1983	1,154	(345)	809	521	288	.621	179	.784	226
1984	1,192	(32)	1,160	563	597	.564	337	.746	445
1985	1,233	149	1,382	801	581	.513	298	.711	413
1986	1,368	(57)	1,311	967	344	.467	161	.677	233
1987	1,424	255	1,679	884	795	.424	337	.645	513
1988	1,483	436	1,919	937	982	.386	379	.614	603
1989	1,583	309	1,892	993	899	.350	315	.585	526
1990	1,647	639	2,286	1,045	1,241	.319	396	.557	691
1991	1,744	696	2,440	-	2,440	.290	708	.530	1,293
1992	1,805	543	2,348	-	2,348	.263	618	.505	1,186
1993	1,786	723	2,509	-	2,509	.239	600	.481	1,207
1994	1,855	(453)	1,402	1,022	380	.218	83	.458	174
1995	1,828	266	2,094	392	1,702	.198	337	.436	742
1996	1,875	226	2,101	419	1,682	.180	303	.416	700
1997	1,870	424	2,294	351	1,943	.164	319	.396	769
1998	1,833	(873)	960	1,487	(527)	.149	(79)	.377	199
1999	1,826	446	2,272	125	2,147	.135	290	.359	771
2000	1,861	323	2,184	132	4,669	.123	574	.342	1,597*
							-2,323		+2,497

Rate of Return = 7.59%

*Includes net asset value of ₱2,617

Total Assets	-	₱ 20,154
Total Liabilities	-	(13,055)
Cash	-	(4,482)
Net Asset Value	-	₱ 2,617

CHAPTER XI ECONOMIC FEASIBILITY ANALYSIS

A. WATER AND THE ECONOMY

Introduction

Water is a basic requirement in any country's economic development and no economic activity can take place without it. However, this basic function diminishes in relative importance as a higher level of economic development is attained by a country. In most instances, the availability of water alone will not spur economic growth for there are other significant factors that influence development, such as peace and order, political stability, rate of taxation and availability of infrastructure facilities. Hence, a water supply project must be considered as only one part of a regional development program. It must be viewed within the context of the overall government program.

Considering that the Philippines is still a developing country, water supply plays a fairly important role in the national or regional economy. Traditionally, water has been made available to the consuming public at very nominal rates. There is a tendency for the consumers to use water wastefully. As a consequence, the regard given to it is far below its true importance.

To the water consumer, the value of water is measured by its contribution to the satisfaction of the family group which uses the water. His perspective includes himself and his household and all the health, well being and productivity aspects of family life. To the businessman, water is valued for all it does to improve business. From the national viewpoint, the benefits to the water user, both householder and businessman, are only a part of the total.

Major Uses of Water Supply

Domestic. Water for domestic use is usually given top priority because water is essential to life and, up to a point, essential to general well-being. Estimation of the beneficial value of water for domestic purposes is best viewed in terms of average willingness to pay for water rather than do without it. It will be noted that the willingness to pay is higher than the price charged insofar as most users are concerned.

Industrial Use. Water is used by industry primarily as a factor of production. In some instances, it goes into the production process as an input. This is the case for the soft drinks industry. One method of determining the value of water to industry is to analyze the cost of alternative industrial processes which produce the same product but use less water. This is not, however, always possible and may be unduly laborious.

Other Uses. Crop irrigation is one of the major uses of water. The value of water used for irrigation purposes can be estimated by an elaborate calculation of "with" and "without" project conditions. All other costs are assumed to be paid and water becomes the residual claimant under "without" and "with" project conditions. Detailed analysis of the area to be irrigated is required.

Another important use is hydropower generation. Water used for this purpose may be valued by comparison with the lowest-cost alternative of providing electric power. Lastly, bodies of water serve a basic role in many recreational activities. Ordinarily, water quality is not adversely affected by recreational use. Water value in this case depends on a number of factors such as accessibility, setting, beauty and quality.

In the Philippines, the National Water Resources Council establishes the water priorities, in pursuance of the policies laid down by its charter, Presidential Decree No. 424. In general, the system of priorities for the development, conservation and utilization of the country's water resources reflects the current usage of water and is responsive to the changing demand for water. Another presidential decree (Presidential Decree No. 198) has declared that the creation, operation, maintenance and expansion of water supply and wastewater disposal systems are a national policy of high priority.

B. METHODOLOGY

Recommended and Next-Best System

One approach in determining the economic feasibility of a water supply project involves a comparison of the benefits and costs of the recommended system and those of the next best system. In this method, the capital expenditure costs and the operating and maintenance costs for both alternative systems are transformed to an equivalent annual cost basis during the projection period. The comparison will show which of the alternative systems will generate the same level of benefits at less cost.

Benefit-Cost Ratio

A second approach in determining the economic feasibility of water supply project involves the following steps:

1. The identification of the economic benefits and costs that can be attributed to the establishment, operation and maintenance of an improved water supply system;

2. The determination of the possible bases for quantifying these benefits and costs; and

3. The comparison of the present value of the benefits likely to be generated and the present value of the costs.

The results of the economic analysis are then expressed as a single ratio called the benefit-cost ratio. The project is considered feasible if the ratio is equal to or greater than 1:1.

Internal Rate of Return

Another method involves the calculation of the economic internal rate of return of the proposed project. The total amount of the benefits as well as of the costs is determined throughout the projection period. By trial and error, the interest rate at which the present worth of the benefits is equal to the present worth of the costs is then calculated. The project is considered desirable if its internal economic rate of return is higher than the minimum rate generally acceptable in such projects, which is usually the opportunity cost of capital.

Method(s) Adopted

Both the second and third methods were employed in determining this project's economic feasibility. These two were considered more appropriate than the first method because in this case, the recommended plan has already been selected from several alternatives on the basis of present worth cost comparisons (as discussed in Chapters VIII and IX).

Calculation of Benefit and Cost Streams

The economic studies cover only Stage I of the proposed water supply program, which extends from 1978 to 1990. Benefits, however, were projected up to 2000. This is because the benefits from the facilities to be constructed up to 1990 would continue to accrue beyond their construction period.

The construction costs included in the analysis are those which will be incurred up to 1990, except replacement costs and the operation and maintenance costs which were projected up to 2000. This is due to the fact that proper maintenance of the facilities will have to be undertaken regularly for as long as benefits are desired to be realized from the system.

Estimates of benefits and costs were based on 1978 prices. In recognition of inflationary pressures, all benefits were escalated by 10 percent from 1978 to 1980, by 8 percent from 1981 to 1985 and by 6 percent from 1986 to 1990. All project costs were also escalated in the same manner, with the exception of operation and maintenance costs which were escalated uniformly by 8 percent all throughout the study period. In both cases, however, the escalation factor for 1990 was held constant up to 2000. This is because only Stage I of the proposed project is being considered in the economic analysis; hence, only partial inflation has been adopted.

C. QUANTIFIABLE BENEFITS

The economic benefits that will be derived from the proposed water supply improvement program for the water district may be classified into quantifiable and non-quantifiable. Quantifiable benefits are those which can be expressed in monetary terms. On the other hand, non-quantifiable benefits are intangible but real, and are extremely difficult to express in monetary terms.

Benefits resulting from the proposed project were evaluated on an incremental basis, i.e., on a "with" or "without" principle. Hence, the benefit figures reflect only those that will accrue to the service area as a result of the improvement of the water supply system. They exclude the benefits arising from the present system.

The quantifiable benefits that are discussed in the following sections are: increase in land values, improved health conditions, reduction in fire damage, and beneficial value.

Increase in Land Values

The implementation of the water supply project will result in an increase in the land values of the service area. However, it must be pointed out that the increase in land values cannot be attributed solely to the water supply project. Any difference between the acquisition cost and the present market value of a piece of land evolves from a series of market and public forces which exist whether or not the water supply project is undertaken. Such forces include the general pace of industrialization, construction activity, inflation, land speculation, taxation, public land acquisition and selling. More particularly, such a difference could be the result of a general estimation of productivity due to infrastructure investments which include a water supply project.

The portion of land values attributable to the provision of an improved public water supply system was estimated in the household survey in Lipa City (May 1975) to be about 22.6 percent of the market value of a piece of land. It is reasonable to assume that this figure represents the incremental value of a piece of land, given access to water supply. In a specific instance, a residential lot about 400 sqm has the following market values:

Without Water	400 sqm x ₱50	=	₱20,000
With Water	400 sqm x ₱65	=	₱26,000
	Ratio	=	1.3 or 30% increase

In this particular case, the incremental cost of ₱6,000 closely represents the market value of a private well (complete with pumps, electric controls, etc) to serve the premises.

On the basis of this information, it may be conservative to assume that 20 percent of the value of land served by the water distribution system could be attributed to the water supply project.

Assumptions made for this analysis are explained in Annex XI-C. Annex Table XI-C-1 shows the computations of this benefit, which amounts to a present worth of ₱6.3 million.

Health Benefits

The establishment of a water supply system in a community will necessarily bring about health benefits to the population. Undoubtedly, the provision of safe, potable water to the population is a prerequisite for the maintenance of minimum health standards. These health benefits are ordinarily manifested in the following:

1. A significant reduction in the incidence of water-borne diseases such as cholera, dysentery, gastro-enteritis, and typhoid/paratyphoid. As a result, there will be a decrease in the amount of time lost by income earners who are afflicted with such diseases.

2. A subsequent reduction in premature deaths due to the lower incidence of water-borne diseases.

3. A corresponding reduction in medical expenses for the same reason.

Calculation for the health benefits and associated assumptions used are presented in Annex XI-C. Annex Table XI-C-2 shows the health benefits on a yearly basis, with a total present worth of ₱262,811.

Reduction in Fire Damage

With the installation of suitable fire hydrants especially in the high-value as well as the residential districts in the service area as part of the proposed project, savings due to reduced fire damages will result from the availability of an adequate amount of water and increased water pressure for fire-fighting purposes. Calculations relative to this benefit are explained in Annex XI-C and shown in detail in Annex Table XI-C-3. The present value of this benefit amounts to ₱1.7 million.

No attempt was made to quantify the inconvenience to the people rendered homeless and the value of human lives lost due to fire.

Beneficial Value of Water

This benefit (sometimes called "consumer satisfaction") is quantified by the additional revenue generated by the water district as a result of an improved water supply project. In the case of a community which previously did not have any piped water system, the "consumer satisfaction" benefit may be measured by the full amount of the economic value of the accounted-for-water.

For a community where the proposed project involves merely the expansion and improvement of the existing system, this benefit may be measured by the economic value of the incremental water production directly resulting from the improvement of the system.

For this benefit, the concept of consumers surplus was adopted. This concept takes into account not only what households and commercial establishments are actually paying for water but also how much more the consumers are willing to pay for this essential commodity. Calculations for the beneficial value of water are shown in Annex XI-C and Annex Table XI-C-4. The present value of this benefit amounts to ₱ 7.5 million.

D. NON-QUANTIFIABLE BENEFITS

The non-quantifiable benefits arising from a water supply project are generally as important as the quantifiable benefits. However, they do not easily lend themselves to valuation. The approach taken herein is to acknowledge their existence and importance. No attempt has been made to quantify or include them in the benefit-cost calculations.

The proposed water supply project will set off a chain of events beyond its construction period. Those activities include among others the inducement to industry to establish plants in the service area due to availability of a dependable water supply. Without such supply, new industrial and commercial establishments would be forced to develop their own supply system or relocate elsewhere. The overall cost of providing separate water systems is normally large and represents a deterrent to invest in the area and consequently to industrial development.

Because of the employment generated by the project, hired laborers are able to spend their wages for purchasing goods at the local stores. Hence, each peso they spend is generated back into the income stream of the local economy. In the operation and maintenance of the project, the water district would find it advantageous to purchase required supplies locally and engage local service.

E. ECONOMIC COSTS

General

The total cost of the proposed water supply system is the sum of all expenditures required to realize project objectives and benefits.

Costs have been divided into the following:

1. Project Costs

2. Replacement Costs

3. Operating and Maintenance Costs

In general, economic costs are easier to identify and quantify than benefits. This is because most of the costs are incurred in real, monetary terms to pay for either goods or services while benefits are usually intangible.

Project Costs

Project costs include the construction cost of the proposed facilities such as pipes, meters and equipment, as well as, engineering services and contingencies, land cost, administrative and legal fees. The cost of the feasibility studies has also been included.

Annex Table XI-E-1 shows the construction costs of the proposed water supply project for the water district. They are listed by component as to type of expenditure in 1978 prices. They are further broken down into foreign and domestic components.

The cost of unskilled labor is shown separately from the domestic component of the project. From the balance of the domestic cost, 5 percent was assumed to be in the form of hidden taxes.

Adjustment on Project Costs

In the determination of the project costs, adjustments were made for those items which are not properly valued by the price mechanism. A price other than the market price (called the shadow price) was imputed to these items. In this way, most of the effects of price discrepancies which could be identified, whether primary or secondary, were incorporated directly into the project analysis and imputed as direct costs to project investment. The 'shadow prices' used in this analysis are those employed by international lending institutions and the Planning and Project Development Office (PPDO) of the Department of Public Works, Transportation and Communication.

One of the items where 'shadow pricing' was applied is the price of unskilled labor (otherwise known as common labor). In a perfectly competitive market, the price of labor is determined by the marginal value of its product. In this case, therefore, the price of labor is equal to the value of the output which an extra laborer hired would produce. However, this is not applicable in an economy such as that of the Philippines where there is a surplus of labor. Since there is widespread disguised unemployment in such an economy, unskilled labor is normally valued below the actual wage rate likely to be paid. In this study, the opportunity cost of unskilled labor or its potential in other employment was valued at one half of its estimated cost in the project. The net effect is to reduce the cost of unskilled labor by 50 percent, thereby reducing the summation of project cost.

Skilled labor, on the other hand, was valued at its going rate. It was assumed that if skilled labor were not employed in the service area, it would probably migrate elsewhere to obtain employment or better wage.

Adjustments were also made with respect to cost of project facilities which use up the limited foreign exchange reserves. Foreign exchange used to import project components was valued at 1.2 times their actual peso cost. This effectively increased foreign exchange cost by 20 percent, thereby affecting project cost in a similar manner. This was done to reflect the opportunity cost or alternative value of foreign exchange. Domestic components, on the other hand, were priced at their actual cost.

Interest was likewise not included since this is considered a financial instead of an economic cost.

Annex Table XI-E-1 shows the conversion of financial costs to economic costs through shadow pricing and other adjustments. The present value (see Table XI-E-4) of total economic project cost for BAN-WD amounts to ₱12.0 million.

Replacement Costs

Based on the criteria used in the financial studies, vehicles have a life expectancy of 7 years while meters are expected to be replaced every 15 years. Other items which have a service life of 15 years are the equipment of the laboratory and meter repair facilities, the administration building as well as those of the distribution facilities, plumbing shop and miscellaneous items of the immediate improvement program. The feasibility studies were assumed to be good for 30 years. All other facilities in the system are expected to last for 50 years.

During the 23-year period from 1978 to 2000, therefore, vehicles, meters, equipment with a service life of 15 years and the miscellaneous items will have to be replaced. Annex Table XI-E-2 shows the replacement schedule and costs of vehicles, meters, equipment and miscellaneous items. The present value of total replacement costs (see Table XI-E-4) for BAN-WD amounts to ₱444,600.

Salvage Value

Annex Table XI-E-3 shows the salvage value in 2001 of all the capital equipment to be used in the project. The percentage of salvage value was based on the remaining service life of the facilities in 2001. For BAN-WD, the present worth of the salvage value (see Table XI-E-4) is ₱6.9 million.

Operating and Maintenance Cost

Operating and maintenance costs refer to the costs associated with the maintenance, operation and management of the project. Otherwise known as annual costs, they include personnel, power, chemicals, and other miscellaneous maintenance expenses such as fuel and lubrication, repairs, communication needs and office rental. Only the operating and maintenance costs of the proposed project (i.e., excluding those of the present system) were considered in this study.

Annex Table XI-E-4 presents the incremental annual recurring costs associated with running and operating the water district up to 2000. The present value of these costs amounts to ₱2.6 million.

Calculation for Economic Costs

The economic cost may be expressed as the adjusted (shadow priced) project cost plus replacement cost plus operating/maintenance cost less salvage value. **Annex Table XI-E-4 shows the** computation of total economic costs for BAN-WD, amounting to ₱13.8 million.

F. BENEFIT-COST ANALYSIS

The summary of the quantifiable economic benefits and economic costs for BAN-WD is shown below. They are expressed in their present values (discounted at 12 percent) after the 1978 prices have been escalated.

SUMMARY OF BENEFITS AND COSTS
(in million pesos)

Benefits		Costs	
Increase in Land Values	₱ 6.300	Project Cost	₱12.023
Health	.263	(+)	
Reduction in Fire Damage	1.660	Replacement Cost	.445
Beneficial Value	7.522	(+)	
	₱15.745	Operating and Maintenance Cost	2.573
		Sub-total	₱15.041
		(-)	
		Salvage Value	1.226
			₱13.815

Benefit Cost Ratio - 1.14:1

The preceding table shows that the quantifiable benefits exceed the economic costs associated with the improvement of the water supply system in BAN-WD. Under the principle of benefit-cost ratio, the project is, therefore, considered economically feasible.

The actual benefits of the proposed project may be really greater than what the benefit-cost ratio represents because the non-quantifiable benefits have not been incorporated into the analysis for obvious reasons.

G. INTERNAL ECONOMIC RATE OF RETURN

The internal economic rate of return (IERR) is the rate at which the present value of the quantifiable benefits is equal to the present value of the economic costs of the proposed project. It is generally held that for a project to be feasible and desirable, its IERR should be higher than the prevailing opportunity cost of capital. In this particular study, the opportunity cost of capital is 12 percent.

For BAN-WD, the IERR is 15.8 percent as shown in Annex Table XI-G-1. On the basis of the above stated principle of IERR, the proposed project appears to be economically feasible and justified.

ANNEX XI-C

QUANTIFIABLE BENEFITS

ANNEX XI-C

QUANTIFIABLE BENEFITS

Portion of Land Values Attributable to Water Supply Project

Annex Table XI-C-1 shows the present value of the portion of land values attributable to the proposed water supply project, based on the following assumptions:

1. In accordance with the staging program of the construction of facilities, the 1980 service area of 155 hectares was projected to increase in the following manner: by 10 hectares from 1980 to 1981; by 11 hectares from 1981 to 1982; by 12 hectares annually from 1982 to 1984; by 13 hectares from 1984 to 1985; by 15 hectares from 1985 to 1986; by 19 hectares from 1986 to 1987; by 12 hectares from 1987 to 1988; by 17 hectares from 1988 to 1989; and by 18 hectares from 1989 to 1990.

2. Land use was assumed to be 88 percent residential and 12 percent commercial/institutional/industrial throughout the projection period. This classification was based on the water demand projections in 1980 by consumer category, as shown in Chapter VI.

3. The 1977 costs of land based on estimated market values in Bangued are:

Residential	:	₱ 12 per sqm
Industrial/Commercial/Institutional	:	₱ 15 " "

These costs were assumed to be constant over the projection period.

4. The portion of the total cost of land specifically attributable to the provision of water supply was assumed to be 20 percent of the cost of land. This land value benefit was escalated by 8 percent from 1980 to 1985, by 6 percent from 1985 to 1990, after which the escalation factor was held constant up to 2000.

5. A discount factor of 12 percent was used to obtain the present values of the benefits. This is believed to be the opportunity cost of capital and is commonly used for public investment projects like water supply development.

For BAN-WD, the land value benefit in its present worth amounts to ₱6.3 million.

ANNEX TABLE XI-C-1

PORTION OF INCREASED LAND VALUES ATTRIBUTABLE TO PROJECT BANGUED WATER DISTRICT

Year	Land Use (sqm) Residential	Land Use (sqm) Commercial/ Institutional/ Industrial	Cost of Land (₱ x 1000) Residential	Cost of Land (₱ x 1000) Commercial/ Institutional/ Industrial	Total Cost of Land (₱ x 1000)	20 Percent Benefit Due to Project (₱ x 1000)	Escalation Factor	Escalated Benefit (₱ x 1000)	Discount Factor at 12%	Present Value of Benefit (₱ x 1000)
1980	1,364,000	186,000	₱16,368.0	₱2,790.0	₱19,158.0	₱ 3,831.6	1.210	₱ 4,636.2	.797	₱3,695.1
1981	88,000	12,000	1,056.0	180.0	1,236.0	247.2	1.307	323.1	.712	230.0
1982	96,800	13,200	1,161.6	198.0	1,359.6	271.9	1.412	384.0	.636	244.2
1983	105,600	14,400	1,267.2	216.0	1,483.2	296.6	1.525	452.4	.567	256.5
1984	105,600	14,400	1,267.2	216.0	1,483.2	296.6	1.647	488.6	.507	247.7
1985	114,400	15,600	1,372.8	234.0	1,606.8	321.4	1.779	571.7	.452	258.4
1986	132,000	18,000	1,584.0	270.0	1,854.0	370.8	1.886	699.3	.404	282.5
1987	167,200	22,800	2,006.4	342.0	2,348.4	469.7	1.999	938.9	.361	338.9
1988	105,600	14,400	1,267.2	216.0	1,483.2	296.6	2.119	628.6	.322	202.4
1989	149,600	20,400	1,795.2	306.0	2,101.2	420.2	2.246	943.9	.288	271.8
1990	158,400	21,600	1,900.8	324.0	2,224.8	445.0	2.[illegible]	1,059.4	.257	272.3
	2,587,200	352,800	₱31,046.4	₱5,292.0	₱36,338.4	₱7,262.6		₱11,126.1		₱6,299.8

Health Benefits

To determine the amount of benefit arising from the reduction of income lost of those afflicted with water-borne diseases, pertinent statistics on morbidity rate were gathered from the Department of Health. From 1964 to 1974, an average of 1,170.6 out of every 100,000 population in the province of Abra were afflicted with primary water-borne diseases every year, regardless of age, sex, and income class. The same rate was assumed for the municipality of Bangued in the absence of specific data. The morbidity rate in the service area was assumed to remain constant during the 21-year projection period.

Since not all of those afflicted with said diseases are wage-earners, an adjustment was made accordingly. Based on the 1970 Census on Population and Housing of the National Census and Statistics Office, 35 percent of the municipality's population was economically active.[1] It was assumed, therefore, that only 35 percent of 1,170.6 per 100,000 who were afflicted with primary water-borne diseases were economically active. Hence, this is the only segment of the population who would suffer a reduction in income due to said diseases. Furthermore, these afflicted wage-earners were assumed to be earning ₱8 a day and unable to work for 15 days on the average because of their illness. The final figure corresponding to the economic cost of time lost due to water-borne diseases was thereby arrived at by multiplying the number of people afflicted with water-borne diseases by 35 percent, by ₱8 a day and then by 15 days.

Another health benefit that could be associated with the establishment of a safe public water supply system is the reduction of the economic cost of the premature death of those afflicted with water-borne diseases in the service area. Obviously, the reduction of the life span of the population caused by said diseases is an economic loss to the community.

This economic loss due to premature death was determined by multiplying the number of people who die because of water-borne diseases (assuming that a water supply improvement program were not undertaken) by 35 percent and then by ₱11,629. The projected number of such deaths was based on the average of the 10-year mortality rate for primary water-borne diseases in the province of Abra, as gathered from the Department of Health. These figures indicated that 44.4 persons died of the 1,170.6 per 100,000 who were

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[1] Economically active population includes those who are 10 years old and over, whether employed or unemployed, excluding retired persons, students and housewives.

afflicted with water-borne diseases. This mortality rate was assumed to be constant over the projection period. The 35 percent corresponds to the portion of the service area population who are income earners. The ₱11,629 represents the monetary valueof each death. This was derived from the estimated income to be earned by the average wage-earner over a period of five years discounted at 12 percent plus 20 percent associated economic costs (summation of ₱200 a month x 12 months x discount factor + 20 percent associated costs).

The third health benefit that can be derived from the improvement of the water supply in the service area is the reduction of the medical expenses of persons afflicted with water-borne diseases. According to the Lipa City pilot survey on "Ability to Pay",[2] an afflicted person spends ₱113.00 annually on the average for medical expenses, which include hospitalization, medicine and doctor's fee. Based on this finding, the total medical expenses incurred due to water-borne diseases were arrived at by multiplying ₱113.00 by the number of people afflicted with such diseases in the service area.

The sum of all three economic costs related to health benefits had to undergo three final adjustments to arrive at more meaningful figures. First, 40 percent of the total economic loss due to water-borne diseases was taken as the health benefit directly resulting from the water supply improvement program. This reduction was made to account for the fact that not all water-borne-diseases are caused by a poor water system and may also be due to less than ideal personal hygiene or lack of sewerage facilities. Second, the 40 percent health benefit was escalated by 8 percent from 1980 to 1985, by 6 percent from 1985 to 1990, after which the escalation factor was held constant up to 2000. Third, the escalated health benefit was discounted to its present worth at 12 percent. Annex Table XI-C-2 shows the calculations associated with the health benefits for BAN-WD. The total present value of said benefits after the adjustments amounts to ₱262,811.

Reduction in Fire Damage

The proposed water supply improvement program will result in increased water pressure and reliable supply for domestic as well as for fire-fighting purposes. At present, it is estimated that approximately 10 percent of the total poblacion of Bangued is covered

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[2] Refer to Methodology Manual, Chapter 20 for "Ability to Pay" studies.

ANNEX TABLE XI-C-2

HEALTH BENEFITS
BANGUED WATER DISTRICT

Year	Served Population	Cost of Time Lost Due To Illness	Economic Loss Due to Premature Death	Cost of Medical Expenses	Total Economic Losses Due To Diseases	40 Percent Reduction Due To Project (Benefit)	Escalation Factor	Escalated Reduction Due To Project (Benefit)	Discount Factor at 12 Percent	Present Value of Health Benefit
1980	10,100	P4,966	P18,252	P13,360	P36,578	P14,631	1.210	P17,704	.797	P 14,110
1981	10,724	5,272	19,350	14,185	38,838	15,535	1.307	20,305	.712	14,457
1982	11,387	5,598	20,578	15,062	41,239	16,496	1.412	23,292	.636	14,814
1983	12,091	5,945	21,850	15,934	43,729	17,516	1.525	26,711	.567	15,145
1984	12,839	6,312	23,202	16,983	46,497	18,599	1.647	30,632	.507	15,531
1985	13,632	6,702	24,635	18,032	49,369	19,743	1.779	35,131	.452	15,879
1986	14,475	7,117	26,158	19,147	52,422	20,969	1.886	39,547	.404	15,977
1987	15,370	7,557	27,776	20,331	55,664	22,266	1.999	44,509	.361	16,068
1988	16,320	8,024	29,493	21,588	59,104	23,642	2.119	50,097	.322	16,131
1989	17,329	8,520	31,316	22,922	62,758	25,103	2.246	56,382	.288	16,238
1990	18,400	9,046	33,251	24,339	66,637	26,655	2.381	63,465	.257	16,311
1991	↓	↓	↓	↓	↓	↓	↓	↓	.229	14,533
1992									.205	13,010
1993									.183	11,614
1994									.163	10,345
1995									.146	9,266
1996									.130	8,250
1997									.116	7,352
1998									.104	6,600
1999									.093	5,902
2000	18,400	9,046	33,251	24,339	66,637	26,655	2.381	63,465	.083	5,268
								1,042,425		P262,811

Total Population 24,587
All Persons 10 Years and Over 27,200
Economically Active: 9,617 or 35%

Morbidity : 1,170.6
Mortality : 44.4

1) $35\% \times \frac{1{,}170.6}{100{,}000} \times$ S.P. x P3 x P15

2) $35\% \times \frac{44.4}{100{,}000} \times$ S.P. x P11,629

3) $\frac{1{,}170.6}{100{,}000} \times$ S.P. x P113

by the existing effective fire hydrant service. With the implementation of the program which will involve the installation of new fire hydrants, the extent of fire protection coverage will be expanded. Hence, a reduction in fire damage is expected in the service area.

This reduction was assumed to be 0.75 percent of the combined assessed values of all structures in the service area. For Bangued, the average assessed value of each structure was assumed to be ₱18,800[3]. The number of structures was derived from the projected population to be served by the system, assuming that each household has an average of 5.7 members[4].

The fire protection benefit was based on the assumed overall reduction in fire damage, but correlated with the schedule of fire hydrant installation in the service area. Percentage of fire protection starts at 10 percent in 1980, gradually increasing to 49 percent in 1990 in accordance with the extent of the service area to be covered by the fire hydrants.

The net reduction in fire damage was escalated by 8 percent from 1980 to 1985, by 6 percent from 1985 to 1990, after which the escalation factor was held constant up to 2000. It was then discounted at 12 percent. The present value of the fire protection benefit, as shown in Annex Table XI-C-3 amounts to ₱1.7 million.

Beneficial Value of Water

Since water is essential to human life, all members of the served population in the service area presumably would be willing to obtain it in sufficient quantities at some given price. With the proposed improvement of the system's facilities, the volume of water production is expected to increase considerably to serve the needs of the growing population. This will bring about additional revenues to the water district, especially since a price increase of water may be justified in view of the improved service.

In general, water rates charged by the water district do not reflect the true value of water. Moreover, it is recognized that households and commercial users are really willing to pay more than what they are actually being charged for water consumed. From the economic viewpoint, therefore, there is a consumers' surplus. This consumers' surplus refers to the additional amount consumers are willing to pay over and above what they are paying for water. For

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[3] In the absence of assessed value records on Bangued, the figure on Gapan was used.

[4] Based on the 1970 Census on Housing in Abra province.

ANNEX TABLE XI-C-3

REDUCTION IN FIRE DAMAGE
BANGUED WATER DISTRICT

Year	Number of Structures 5/	Total Value at P18,800 each 6/	Overall Reduction in Fire Damage (.0075)	Percentage Protection (Benefit)	Net Reduction in Fire Damage	Escalation Factor 7/	Escalated Value of Net Reduction	Discount Factor at 12%	Present Value of Net Benefit
1980	1,772	P33,313.6	P249,852	10%	P 24,985	1.210	P 30,232	.797	P 24,095
1981	1,882	35,381.6	265,362	13	34,497	1.307	45,088	.712	32,102
1982	1,998	37,562.4	281,718	16	45,074	1.412	63,644	.636	40,478
1983	2,121	39,874.8	299,061	20	59,812	1.525	91,214	.567	51,718
1984	2,252	42,337.6	317,532	26	82,558	1.647	135,973	.507	68,938
1985	2,392	44,969.6	337,272	33	111,300	1.779	198,003	.452	89,497
1986	2,539	47,733.2	357,999	36	128,880	1.886	243,068	.404	98,199
1987	2,696	50,684.8	380,136	39	148,253	1.999	296,358	.361	106,985
1988	2,863	53,824.4	403,683	42	169,547	2.119	359,270	.322	115,685
1989	3,040	57,152	428,640	45	192,888	2.246	433,226	.288	124,769
1990	3,228	60,686.4	455,148	49	223,023	2.381	531,017	.257	136,471
1991								.229	121,603
1992								.205	108,898
1993								.183	97,176
1994								.163	86,556
1995								.146	77,528
1996								.130	69,032
1997								.116	61,598
1998								.104	55,226
1999								.093	49,385
2000	3,228	60,686.4	455,148	49	223,023	2.381	531,017	.083	44,074
								TOTAL	1,659,973

5/ Derived from the served population projections, assuming that there are 5.7 members per household according to the 1970 Census on Housing in Abra.

6/ Based on the assessed value records in Gapan in the absence of similar data on Bangued.

7/ Escalated annually by 10 percent from 1978 to 1980, by 8 percent from 1980 to 1985 and by 6 percent from 1985 to 1990, after which the escalation factor was held constant up to 2000.

purposes of this study, this additional value has been estimated to be 50 percent higher than domestic water rates and 25 percent higher than commercial/industrial/institutional water rates[8].

In the determination of this benefit, the following steps were taken:

1. Only the incremental volume of accounted-for-water was considered; hence, the 1977 accounted-for-water amounting to 154,395 cum was deducted from total accounted-for-water projections in Chapter VI. The water demand projections in Chapter VI, expressed in liters per capita per day, were converted to cubic meters per year.

2. Classification of accounted-for-water into domestic and others (commercial/institutional/industrial) was based likewise on Chapter VI.

3. The price per cubic meter of water was obtained from the unescalated rate per revenue unit in Chapter X, Annex Table X-C-1. The rates were, however, adjusted upwards to reflect consumers' surplus: 50 percent higher for domestic water and 25 percent higher for others.

4. The net economic revenues were obtained by subtracting the assumed 1977 revenues of BAN-WD of ₱47,700 from total economic revenues. The net economic revenues may be considered as benefits of the proposed project since revenues of the existing system have been duly excluded.

5. The net economic revenues were then escalated by 10 percent from 1978 to 1980, by 8 percent from 1980 to 1985, by 6 percent from 1985 to 1990, after which the escalation factor was held constant up to 2000. Finally, the escalated values were discounted at 12 percent to obtain their present values.

For BAN-WD, the beneficial value of water amounts to a present value of ₱13.0 million, as shown in Annex Table XI-C-4.

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[8] Refer to Procedures for the Economic and Financial Analysis of Water Projects, LWUA, May 1976.

ANNEX TABLE XI-C-4

BENEFICIAL VALUE OF WATER
BANGUED WATER DISTRICT

Year	Incremental Accounted-For-Water cum/year 9/	Domestic cum/year	Others cum/year	Price Per cum 10/ Domestic	Price Per cum 10/ Others	Economic Value Per cum 11/ Domestic	Economic Value Per cum 11/ Others	Economic Water Revenues Domestic	Economic Water Revenues Others	Total Economic Revenue	Escalation Factor 12/	Escalated Economic Revenue	Discount Factor at 12 Percent	Present Value of Economic Revenue
1977	154,395													
1978	70,047	61,641	8,406	.70	1.40	1.05	1.75	64,723	14,711	79,434	1.000	79,434	1.000	79,434
1979	147,197	129,533	17,664	.65	1.30	.98	1.63	126,942	28,792	155,734	1.100	171,307	.893	152,978
1980	239,805	211,028	28,777	.60	1.20	.90	1.50	189,925	43,166	233,091	1.210	282,040	.797	224,786
1981	272,261	239,590	32,671	.95	1.90	1.43	2.38	342,614	77,757	420,371	1.307	549,425	.712	391,191
1982	305,660	268,998	36,662	.88	1.76	1.32	2.20	355,077	80,700	435,777	1.412	615,317	.636	391,342
1983	342,335	301,299	41,036	.82	1.64	1.23	2.05	370,598	84,226	454,824	1.525	693,607	.567	393,275
1984	382,505	336,604	45,901	1.01	2.02	1.52	2.53	511,638	116,130	627,768	1.647	1,033,934	.507	524,204
1985	423,765	372,913	50,852	.94	1.88	1.41	2.35	525,807	119,502	645,309	1.779	1,148,005	.452	518,898
1986	468,616	412,382	56,234	.86	1.72	1.29	2.15	531,973	120,903	652,876	1.886	1,231,324	.404	497,455
1987	517,190	455,127	62,063	.90	1.80	1.35	2.25	614,421	139,642	754,063	1.999	1,507,372	.361	544,161
1988	569,619	501,265	68,354	.83	1.66	1.25	2.08	626,581	142,176	768,757	2.119	1,628,996	.322	524,537
1989	626,033	550,909	75,124	.77	1.54	1.16	1.93	639,054	144,989	784,043	2.246	1,760,961	.288	507,157
1990	686,565	604,177	82,388	.75	1.50	1.13	1.88	682,720	154,889	837,609	2.381	1,994,347	.257	512,546
1991				.70	1.40	1.05	1.75	634,386	144,179	778,565		1,853,763	.229	424,512
1992				.65	1.30	.98	1.63	592,093	134,292	726,385		1,729,523	.205	354,552
1993				.66	1.32	.99	1.65	598,135	135,940	734,075		1,747,833	.183	319,853
1994				.61	1.22	.92	1.53	555,843	126,054	681,897		1,623,597	.163	264,646
1995				.57	1.14	.86	1.43	519,592	117,815	637,407		1,517,666	.146	221,579
1996				.55	1.10	.83	1.38	501,467	113,695	615,162		1,464,701	.130	190,441
1997				.51	1.02	.77	1.28	465,216	105,457	570,673		1,358,772	.116	157,618
1998				.47	.94	.71	1.18	428,966	97,218	526,184		1,252,844	.104	130,296
1999	↓	↓	↓	.44	.88	.66	1.10	398,757	90,627	489,384	↓	1,165,223	.093	108,366
2000	656,565	604,177	82,388	.40	.80	.60	1.00	362,506	82,388	444,894	2.381	1,059,293	.083	87,921
												27,459,284		7,531,720

9/ The 1977 figure of 224,687 cum per year of accounted-for-water was deducted from the water demand projections throughout the study period to obtain the incremental volume.

10/ Based on the unescalated rate per revenue unit of water in the financial studies, the rate for 'others' was assumed to be twice that for domestic.

11/ Assumed to be 50 percent higher than domestic rates and 25 percent higher than rates for commercial/industrial/institutional consumers.

12/ Escalated annually by 10 percent from 1978 to 1980, by 8 percent from 1980 to 1985 and by 6 percent from 1985 to 1990, after which the escalation factor was held constant up to 2000.

ANNEX XI-E

ECONOMIC COSTS

ANNEX TABLE XI-E-1

CONVERSION OF FINANCIAL COST TO ECONOMIC COST
BANGUED WATER DISTRICT

	Financial Project Cost	Foreign Exchange Component	Domestic Cost Component	Unskilled Labor	Balance of Domestic Component 14/	Taxes 15/ (5%)	Others (95%)	SHADOW PRICING: Foreign Exchange Component x 1.2	SHADOW PRICING: Unskilled Labor x .5	SHADOW PRICING: Others x 1.0	Economic Project Cost 16/	Economic Construction Cost 17/
Source Development	258,000	148,620	109,380	62,330	47,050	2,353	44,697	178,344	31,165	44,697	254,207	200,954
Distribution Facilities	4,994,000	2,555,779	2,438,221	454,020	1,984,201	99,210	1,884,991	3,066,935	227,010	1,884,991	5,178,936	4,094,021
Internal Network	1,649,000	708,070	940,930	183,260	757,670	37,884	719,786	849,684	91,630	719,786	1,661,100	1,438,182
Service Connections												
a) Pipes	847,000	412,098	434,902	328,112	106,790	5,340	101,450	294,518	164,056	101,450	760,024	658,029
b) Meters	322,000	268,759	53,241	40,168	13,073	654	12,419	322,511	20,084	12,419	355,014	307,371
Fire Hydrants	275,000	160,542	114,458	26,180	88,278	4,414	83,864	192,650	13,090	83,864	289,604	250,739
Laboratory Facilities												
a) Equipment	310,000	275,944	34,056	18,591	15,465	773	14,692	331,133	9,296	14,692	355,121	280,728
b) Structure	213,000	70,096	142,904	78,009	64,895	3,245	61,650	84,115	39,005	61,650	184,770	146,063
Meter Repair Facilities												
a) Equipment	76,000	68,425	7,575	3,306	4,269	213	4,056	82,110	1,653	4,056	87,819	69,422
b) Structure	69,000	4,111	64,889	28,319	36,570	1,829	34,741	4,933	14,160	34,741	53,834	42,557
Plumbing Shop	459,000	27,134	431,866	62,560	369,306	18,465	350,841	32,561	31,280	350,841	414,682	327,812
Vehicles	69,000	35,145	33,855	-	33,855	1,693	32,162	42,174	-	32,162	74,336	64,860
Feasibility Studies	96,000	53,760	42,240	-	42,240	2,112	40,128	64,512	-	40,128	104,640	82,719
Immediate Improvements												
a) Distribution Facilities												
1. Equipment	28,000	25,357	2,643	486	2,157	108	2,049	30,428	243	2,049	32,720	25,866
2. Structure	1,731,000	925,543	805,457	147,979	657,478	32,874	624,604	1,110,652	73,989	624,604	1,809,255	1,430,233
b) Administation Building												
1. Equipment	113,000	86,003	26,997	3,681	23,316	1,166	22,150	103,204	1,841	22,150	127,195	100,549
2. Structure	459,000	27,134	431,866	58,[illegible]9	372,987	18,649	354,338	32,561	29,440	354,338	416,339	329,122
c) Storage Facilities	36,000	20,530	15,470	7,130	8,340	417	7,923	24,636	3,565	7,923	36,124	28,557
d) Service Connections												
1. Pipes	571,000	280,411	290,589	95,544	195,045	9,752	185,293	336,493	47,772	185,293	569,558	450,243
2. Meters	395,000	329,179	65,821	21,641	44,180	2,209	41,971	395,015	10,821	41,971	447,807	353,998
e) Vehicles	76,000	38,980	37,020	-	37,020	1,851	35,169	46,776	-	35,169	81,945	64,779
f) Miscellaneous Items	16,000	10,170	5,830	-	5,830	292	5,538	12,204	-	5,538	17,742	14,025
g) Feasibility Studies	35,000	19,600	15,400	-	15,400	770	14,630	23,520	-	14,630	38,150	30,1[illegible]
Sub-Total	13,097,000	6,551,390	6,545,610	1,620,195	4,925,415	246,273	4,679,142	7,861,669	810,100	4,679,143	13,350,912	10,790,[illegible]37
Land	103,000	-	103,000	-	103,000	5,150	97,850	-	-	97,850	97,850	97,850
Total Project Cost	13,200,000	6,551,390	6,643,610	1,620,195	5,028,415	251,423	4,776,992	7,861,669	810,100	4,776,993	13,448,762	10,888,337

14/ Domestic cost component less unskilled labor cost.
15/ Computed at 5 percent of domestic component after unskilled labor was deducted from it.
16/ Obtained by adding together foreign exchange cost, unskilled labor cost and cost of 'other' after they have been adjusted through shadow pricing.
17/ Derived by subtracting contingencies and engineering services from the economic project cost.

ANNEX TABLE XI-E-2

REPLACEMENT COST
BANGUED WATER DISTRICT
1978 PRICES
(₱ x 1000)

Year	Vehicles	Meters	Equipment	Miscellaneous Items	Total
1978					
1979					
1980					
1981					
1982					
1983					
1984					
1985					
1986	₱ 64.8				₱ 64.8
1987	64.4				64.4
1988					
1989					
1990					
1991					
1992					
1993					
1994	64.8	132.8	126.4	14.0	338.0
1995	64.4	110.1	-		174.5
1996		117.3	22.5		139.8
1997		29.5	164.3		193.8
1998		29.5	163.3		192.8
1999		29.5	-		29.5
2000		29.5	-		29.5
Total	₱ 258.4	₱ 478.2	₱ 476.5	₱ 14.0	₱ 1,227.1

ANNEX TABLE XI-E-3

SALVAGE VALUE IN 2 1
BANGUED WATER DISTRICT
1978 PRICES

	50 Years			30 Years			15 Years			7 Years			Infinite			
	Economic Value	Remaining Service Life in 2001 (in Percent)	Salvage Value	Economic Value	Remaining Service Life in 2001 (in Percent)	Salvage Value	Economic Value	Remaining Service Life in 2001 (in Percent)	Salvage Value	Economic Value	Remaining Service Life in 2001 (in Percent)	Salvage Value	Economic Value	Remaining Service Life in 2001 (in Percent	Salvage Value	Total Salvage Value[18]
1978	1,962.0	56%	1,095.8	30.2	27%	8.2							80.3	100%	80.3	1,184.3
1979	156.2	58	90.6													90.6
1980	420.9	60	252.5	82.7	33	27.3							17.6	100	17.6	297.4
1981	2,115.0	62	1,311.3													1,311.3
1982	2,113.6	64	1,352.7													1,352.7
1983	264.7	66	174.7													174.7
1984	264.7	68	158.8													158.8
1985	352.0	70	246.4													246.4
1986	352.9	72	254.1				29.5	7%	2.1							256.2
1987	352.9	74	261.1				29.5	13	3.8							264.9
1988	352.9	76	268.2				29.5	20	5.9							274.1
1989	352.9	78	275.3				29.5	27	8.0							283.3
1990	335.8	80	268.6				29.5	33	9.7							278.3
1991																-
1992																-
1993																-
1994							273.2	60	164.0	64.8	14%	9.1				173.1
1995							110.1	67	73.8	64.4	29	18.7				92.5
1996							139.8	73	102.1							102.1
1997							193.8	80	155.0							155.0
1998							192.8	87	167.7							167.7
1999							29.5	93	27.4							27.4
2000							65.2	100	65.2							65.2
	₱9,396.5		₱6,010.1	₱112.9		₱35.5	₱1,151.9		₱784.7	₱129.2		₱27.8	₱97.9		₱97.9	₱6,956.0

Total Economic Value: ₱10,888.4
Total Salvage Value : ₱ 6,956.0

18/ Salvage values for each year are actually the salvage value of the item in year 2001.

ANNEX TABLE XI-E-4

SUMMARY OF ECONOMIC COSTS
[illegible] WATER DISTRICT
(₱ x 1000)

	Project Cost	Replacement Cost	Salvage Value	O and M Costs	Total Costs	Escalation Factor For Other Costs 19/	Escalation Factor For O and M Costs 20/	Escalated Project Cost	Escalated Replacement Cost	Escalated O and M Cost	Escalated Total Costs	Discount Factor at 12 Percent	Present Value of Project Cost	Present Value of Replacement Cost	Present Value of O and M Costs	Present Value of Total Costs
1978	₱ 3,027.8			36.7	3,064.5	1.000	1.000	3,027.8		36.7	3,064.5	1.000	3,027.8		36.7	3,064.5
1979	590.4			64.1	654.5	1.100	1.080	649.4		69.2	718.6	.893	579.9		61.8	641.7
1980	826.1			93.3	919.4	1.210	1.166	999.6		108.8	1,108.4	.797	796.7		86.7	883.4
1981	2,799.3			172.1	2,971.4	1.307	1.260	3,658.7		216.8	3,875.5	.712	2,605.0		154.4	2,759.4
1982	2,796.1			179.6	2,975.7	1.412	1.360	3,948.1		244.3	4,192.4	.636	2,511.0		155.4	2,666.4
1983	339.8			186.9	526.7	1.525	1.469	518.2		274.6	792.8	.567	293.8		155.7	449.5
1984	339.8			194.1	533.9	1.647	1.587	559.7		303.0	867.7	.507	283.8		156.2	440.0
1985	453.5			202.2	655.7	1.779	1.714	806.8		346.6	1,153.4	.452	364.7		156.7	521.4
1986	459.5	64.8		208.1	732.9	1.886	1.851	866.6	122.2	386.1	1,374.9	.404	350.1	49.4	156.0	555.5
1987	459.5	64.4		211.7	735.3	1.999	1.999	918.5	128.7	423.2	1,470.4	.361	331.6	46.5	152.8	530.9
1988	459.5			214.5	674.0	2.119	2.159	973.7		463.1	1,436.8	.322	313.5		149.1	462.6
1989	459.5			218.1	677.6	2.246	2.332	1,032.0		508.6	1,540.6	.288	297.2		146.5	443.7
1990	438.0			233.5	671.5	2.381	2.518	1,042.9		588.0	1,630.9	.257	268.0		151.1	419.1
1991					233.5						588.0	.229			134.7	134.7
1992					233.5						588.0	.205			120.5	120.5
1993					233.5						588.0	.183			107.6	107.6
1994		338.0			571.5				804.8		1,392.8	.163		131.2	95.8	227.0
1995		174.5			408.0				415.5		1,003.5	.146		60.7	85.8	146.5
1996		139.8			373.3				332.9		920.9	.130		43.3	76.4	119.7
1997		193.8			427.3				461.4		1,049.4	.116		53.5	68.2	121.7
1998		192.8			426.3				459.1		1,047.1	.104		47.7	61.2	108.9
1999		29.5			263.0				70.2		658.2	.093		6.5	54.7	61.2
2000		29.5		233.5	263.0	2.381	2.518		70.2	588.0	658.2	.083		5.8	48.8	54.6
	₱13,448.8	₱1,227.1		4,550.4	19,226.3			19,001.1	2,865.0	9,854.0	31,721.0		12,023.1	444.6	2,572.8	15,040.5
Salvage Value			₱6,956.0		6,956.0	2.381					-16,562.2	.074				-1,225.6
					12,270.3						15,158.8					13,814.9

19/ Project cost and replacement cost were escalated annually by 10 percent from 1976 to 1980, by 8 percent from 1980 to 1985, by 6 percent from 1985 to 1990, after which the escalation factor was held constant up to 2000.

20/ Operating and maintenance costs were escalated annually by 8 percent from 1978 to 1990, after which the escalation factor was held constant up to 2000.

ANNEX XI-G

INTERNAL ECONOMIC RATE OF RETURN

ANNEX TABLE XI-G-1

INTERNAL ECONOMIC RATE OF RETURN
BANGUED WATER DISTRICT
(₱ x 1000)

Year	Escalated Values: Benefits	Escalated Values: Costs	Discount Factor at 15 Percent	Present Value at 15 Percent: Benefits	Present Value at 15 Percent: Costs	Discount Factor at 20 Percent	Present Value at 20 Percent: Benefits	Present Value at 20 Percent: Costs
1978	79.4	3,064.5	1.000	79.4	3,064.5	1.000	79.4	3,064.5
1979	171.3	718.6	.870	149.0	625.2	.833	142.7	598.6
1980	4,966.1	1,108.4	.756	3,754.4	838.0	.694	3,446.5	769.2
1981	937.9	3,875.5	.658	617.1	2,550.1	.579	543.0	2,243.9
1982	1,086.2	4,192.4	.572	621.3	2,398.1	.482	523.5	2,020.7
1983	1,263.9	792.8	.497	628.2	394.0	.402	508.1	318.7
1984	1,689.1	857.7	.432	729.7	374.8	.335	565.8	290.7
1985	1,952.8	1,153.4	.376	734.3	433.7	.279	544.8	321.8
1986	2,213.2	1,374.9	.327	723.7	449.6	.233	515.7	320.4
1987	2,787.1	1,470.4	.284	791.5	417.6	.194	540.7	285.3
1988	2,667.0	1,436.8	.247	658.8	354.9	.162	432.1	232.8
1989	3,194.5	1,540.6	.215	686.8	331.2	.135	431.3	208.0
1990	3,648.3	1,630.9	.187	682.2	305.0	.112	408.6	182.7
1991	2,448.3	588.0	.163	399.1	95.8	.094	230.1	55.3
1992	2,324.0	588.0	.141	327.7	82.9	.078	181.3	45.9
1993	2,342.3	588.0	.123	288.1	72.3	.065	152.3	38.2
1994	2,218.1	1,392.8	.107	237.3	149.0	.054	119.8	75.2
1995	2,112.2	1.003.5	.093	196.4	93.3	.045	95.1	45.2
1996	2,059.2	920.9	.080	164.7	73.7	.038	78.3	35.0
1997	1,953.3	1,049.4	.070	136.7	73.5	.031	60.6	32.5
1998	1,847.4	1,047.1	.061	112.7	63.9	.026	48.0	27.2
1999	1,759.7	658.2	.053	93.3	34.9	.022	38.7	14.5
2000	1,653.8	658.2	.046	76.1	30.3	.018	29.8	11.8
	47,375.1			12,888.5			9,716.2	
		31,721.0			13,306.3			11,238.1
Salvage Value –		16,562.2	.040		662.5	.015		248.4
		15,158.8			12,643.8			10,989.7
	1.00	0.32		1.00	0.98		1.00	1.13

Present Value at 15% = 244.7
Present Value at 20% = (1,273.5)
1,518.2

$$IERR = .15 + \frac{.05(244.7)}{1,518.2}$$
$$= .15 + .0081$$
$$= 15.8\%$$

M E T H O D O L O G Y

M E M O R A N D A

Methodology Memorandum No. 1

To : L. V. Gutierrez, Jr.

From : A. de Vera

Date : 4 January 1977

Subject: Pilot Area Survey

A. Need

In estimating water accountability, data on the ratio of borrowers to primary users, average persons per household, and per capita consumption are necessary. Information on capacity and willingness-to-pay would greatly aid financial analysis. In all cases, these data are not readily available in the Philippines. The only way to get these data would be to actually perform a house-to-house survey within the served areas of the water district (WD). Considering time and financial constraints, a pilot area survey would be the best approach. This is merely surveying a representative area within the WD and projecting the data obtained for the entire served area of the WD.

B. Methodology

1. Choose a pilot area within the WD. Desirable requirements for the area are as follows:

   a. adequate line pressures, preferably with 24-hour service;
   b. metered connections;
   c. presence of domestic as well as commercial connections. Ratio of commercial to domestic connections for the area must not exceed that for the entire WD;
   d. representative income levels of the concessionaires.

2. Devise a one-page questionnaire so that it:

   a. is easily understood by WD personnel (who will serve as interviewers);
   b. provides relevant information;
   c. provides a means of cross-checking some answers given by respondents;
   d. would make tabular analysis easy.

   A sample questionnaire is attached.

3. Get assistance from the WD personnel in the house-to-house survey. It is suggested that they do the actual interview because of their familiarity with local customs and dialects. However, before allowing the WD enumerators to proceed on their own, it is necessary that:

   a. the enumerators be given a thorough briefing on the importance of the survey, as well as the purpose of each item in the questionnaire.
   b. the enumerators be accompanied to the first few houses, and given additional pointers or feedback before they proceed on their own.

4. Conduct a house-to-house survey of all households within the pilot area. A map at this point indicating the existing houses (with their code numbers) would be necessary. The following would be helpful during the survey:

   a. brief the respondents about the purpose of the survey before asking questions. It is very important that they be receptive to the interviewers. Otherwise data given could be misleading.
   b. in asking for estimates of consumption, avoid using technical terms, i.e., liters, gallons, etc. Use local containers like pails, drums or whatever they use. Note the capacity of the container in the questionnaire.

C. <u>Data</u>

The following data may be obtained from the survey:

1. Pilot area density
2. Average persons/household
3. Borrowers from connected households and percentage of households dependent on the WD
4. Potential concessionaires
5. Consumption estimates
6. Income levels and the respective rates showing willingness to pay for improved service
7. Water accountability

[redacted] WATER DISTRICT
PILOT AREA QUESTIONNAIRE

DATE ____________
TIME ____________

INTERVIEWEE ____________ ADDRESS ____________

TYPE OF DWELLING ____________ CONSTRUCTION MATERIAL ____________

WD CONCESSIONAIRE

1. NO. OF OCCUPANTS: ______
2. CLASSIFICATION:
   - ☐ Domestic
   - ☐ Commercial
   - ☐ Institutional
   - ☐ Industrial
   - ☐ ______
3. SIZE OF CONNECTION:
   - ☐ ½" ☐ 1" ☐ 2"
   - ☐ ¾" ☐ 1½" ☐ ______
4. TYPE OF CONNECTION:
   - ☐ metered: meter functioning
   - ☐ metered: meter damaged
   - ☐ flat rate (unmetered)
5. APPURTENANCES (Connected to System)
   - ☐ with hand pump
   - ☐ with electric motor pump
   - HRS used/day ______
   - Pump rated HP ______
   - GPM ______
   - ______
6. OTHER SOURCE ASIDE FROM WD:

Own	Other HH
☐ wells	☐ wells
☐ springs	☐ springs
☐ rainwater	☐ rainwater
☐ ______	☐ ______

NON-WD CONCESSIONAIRE

1. NO. OF OCCUPANTS: ______
2. SOURCE OF SUPPLY:
   - ☐ own private well
   - ☐ rainwater
   - ☐ spring
   - ☐ public faucet
   - ☐ WD concessionaire HH Code No. ______
   - ☐ public well
   - ☐ others' private well
   - ☐ ______
3. CONSUMPTION:
   - ☐ free
   - ☐ paying
   - volume used per day ______
   - Paying ₱______
   - for ______.

REMARKS:

FOR ALL HOUSEHOLDS

1. WD-WATER AVAILABLE:
   - No. of hours ______
   - Time ______
2. FAUCETS:
   - ☐ 1 ☐ 3 ☐ 5
   - ☐ 2 ☐ 4 ☐ ______
3. SHOWERS:
   - ☐ 1 ☐ 2 ☐ 3 ☐ ______
4. FLUSH WATER CLOSET:
   - ☐ 1 ☐ 2 ☐ 3 ☐ ______
5. MANUAL WATER CLOSET:
   - ☐ 1 ☐ 2 ☐ 3 ☐ ______
6. ☐ w/septic tank ☐ w/o septic tank
7. AVERAGE MONTHLY:

	Consumption	Billing/PYMT
WD:	______	______
wells:	______	______
others:	______	______

8. USER:
   - ☐ w/ borrowers
   - ☐ w/o borrowers
   - Total no. of HH borrowers ______
   - Total no. of HH borrowers occupants ______
9. How much would you be willing to pay if water service were improved? ______/month.

(TO BE FILLED UP AT THE WD OFFICE)

1. HOUSEHOLD CODE NO. ______
2. INCOME:
   - ☐ below average (₱220 below)
   - ☐ average (₱221 - 750)
   - ☐ upper middle (₱751 - 1,500)
   - ☐ high (₱1,500 above)
3. WD CONCESSIONAIRE:
   - ☐ registered
   - ☐ unregistered
4. PAYMENTS:
   - ☐ up-to-date
   - ☐ delinquent

______
ENUMERATOR

______
POSITION

Methodology Memorandum No. 2

To : L. V. Gutierrez, Jr.

From : A. de Vera

Date : 31 January 1977

Subject: Estimating Water Accountability

A. Need

To be able to determine future water demand per capita, need for leak detection and survey program, and the level of development possible for reducing wastage and leakage, the following information must first be available.

1. Ratio of accounted-for and unaccounted-for-water.

2. Ratio of wastage and leakage in relation to total production.

3. Domestic consumption per capita.

Although there are various methods for estimating water accountability, the selection of a method depends on the purpose for which it is to be used and the level of accuracy desired. Accounted-for-water as used herein refers to the revenue-producing water for the water district. It is the sum of the billed metered consumption and inferred water consumption at flat-rate connections.

B. Methodology

1. Pilot Area Survey

a. Objective - To be able to estimate total accounted-for and unaccounted-for-water. Accuracy will depend on the reliability of the consumption figures as obtained in the pilot area survey.[1]

b. Data Necessary - Monthly production; number of metered and unmetered connections; water rate schedule; pilot area data; and total monthly metered consumption.

---

[1] Refer to Methodology Memorandum No. 1.

c. Steps

1) Obtain total number of households dependent on water system. To do this, first obtain ratio of households dependent on the system to total households in the pilot area and apply ratio to the whole service area. Compute for number of primary and secondary users.

2) Compute for inferred flat-rate use per month.

3) Compute total accounted-for-water by adding average monthly metered consumption and total inferred flat-rate use per month.

4) Unaccounted-for-water is total production less accounted-for-water. It is also the total of potentially billable water plus wastage, leakage and other uses.

5) Potentially billable water is the sum of:

- o Usage of borrowers from flat-rate primary users;
- o Unbilled flat-rate use
- o Wastage of flat-rate users

2. Weighted Average of First 10-City Survey

a. Objective - In a water system with all functions billed as flat-rate, computing for water accountability is impossible without resorting to detailed surveys. However, this method implies that the figures obtained during the first 10-area survey (CDM - 1975) approximate those of other water districts. Accuracy, however, is not determined.

b. Data Necessary - Total monthly production and figures obtained during the First 10-Area Survey of CDM.

c. Steps

Multiply monthly production by:

.31 to get accounted-for-water
.11 to get underestimated flat-rate use
.26 to get wastage
.25 to get leakage
.07 for others

3. Field Study Method

a. Objective - To be able to determine within ± 5 percent accuracy water accountability figures. This method, however, is time-consuming and very expensive.

b. Data Necessary - All data received shall be generated in the field. The number of concessionaires and the water rate schedule are basic requirements.

c. Steps

1) For each section of transmission and distribution line in the water system, appropriate measuring devices shall be installed in order to determine the amount of water flowing in and out, water used by the concessionaires, and water leakage.

2) Desk-top analysis is then necessary to determine water accountability.

METHODOLOGY MEMORANDUM NO. 3

To : L. V. Gutierrez, Jr.

From : P. del Rosario

Date : 8 February 1977

Subject: Classification of Water Districts According to Future Water Requirements

A. Introduction

The purpose of this methodology manual is to classify water districts (WD) so that future water requirements may be estimated. The factors to be considered in classifying WD's are economic and social development in the district's boundaries, probable sources of additional water supply and the people's ability-to-pay for improved water service.

The group with the probable highest per capita consumption is labelled Group I; and the group with the probable lowest water consumption, Group V. Affluent and highly urbanized water districts may fall under Group I, while less developed and small water districts, under Group V.

B. Methodology

The initial service area of the WD will most likely include the central urban area or core city (poblacion). To classify it according to future water demands, the WD and its central urban area are judged according to 5 grouping criteria - 1975 urban income, 1975 standard of living, 1975 business index, 1980 cost of water, and served population in 1980. For each criterion, a number of points, from 0 to 20, are allotted to each water district. The total number of points under the 5 criteria determines the classification of the WD.

Table MM 3-1 lists the 5 criteria by which the WD can be classified, and the points allotted to rankings in each criterion.

The grouping of the WD's based on the range of total points under the 5 criteria is as follows:

TABLE MM 3-1

WATER DISTRICT GROUPING CRITERIA

1975 Urban Income		1975 Standard of Living				1975 Business Index		1980 Cost of Water		1980 Served Population	
Income Taxes Paid by Urban Residents (P)	Points 20	% of Households with Refrigerators in Urban Area	Points 10	% of Households with Flush Toilets in Urban Area	Points 10	% of Commercial Establishments in Urban Area	Points 20	Source of Additional Water Supply	Points 20	Population Served in Urban Area	Points 20
more than 30,000,000	20	more than 30	10	more than 60	10	more than 6.6	20	Spring, gravity type	20	more than 150,000	20
10,000,001-30,000,000	18	25.1 - 30	9	50.1 - 60	9	4.6 - 6.6	16			100,001 - 150,000	18
5,000,001-10,000,000	16	20.1 - 25	8	40.1 - 50	8	3.1 - 4.5	11				
								Spring with booster pump	17	80,001 - 100,000	16
1,000,001- 5,000,000	14	15.1 - 20	7	30.1 - 40	7	1.7 - 3.0	7				
								Infiltration with short transmission line/ well points	14	65,001 - 80,000	14
500,001- 1,000,000	12	10.1 - 15	6	20.1 - 30	6	1.0 - 1.6	4			52,001 - 65,000	12
100,001- 500,000	10	5 - 10	5	10 - 20	5	less than 1	2				
								Infiltration with long transmission line/ wells	11	41,001 - 52,000	10
50,001- 100,000	8	less than 5	4	less than 10	4					31,001 - 41,000	9
20,001- 50,000	6										
								Surface water without reservoir	7	22,001 - 31,000	8
8,001- 20,000	4										
								Surface water with reservoir	5	15,001 - 22,000	7
4,001- 8,000	2									10,001 - 15,000	6
4,000 or less	1									less than 10,000	5

Group	Total Points
I	70 and above
II	60 - 69
III	50 - 59
IV	40 - 49
V	39 and below

In allotting points under each criterion, readily available data are taken from the latest NCSO report (1970 or 1975 census). These data are: total population in the city or municipality; total households; number of urban households; number of commercial establishments; number of industrial establishments; number of households with refrigerators; and number of households using flush water-sealed toilets. The data on total income taxes paid in the city/municipality in 1975 were obtained from the BIR office. Data on the probable sources of additional water supply were taken from the recent preliminary hydro-survey conducted by LWUA and the WD.

The following is a procedure for assigning points to a WD on the basis of the 5 criteria.

1. 1975 Urban Income

    Urban income is based on the total income taxes paid by individuals and business entities and the percentage of urban households with respect to total households in the city/municipality. If the 1975 data are not available, the percentage of urban households is projected to 1975 by applying an increase of 0.1 to 0.4 percent per year. In projecting the percentage of urban households, growth characteristics and urban development must be considered. The projected percentage is multiplied by 1975 total income. Table MM 3-1 shows the breakdown of the annual income with points ranging from 1 to 20.

2. 1975 Standard of Living

    The standard of living is measured by the number of households in the urban area with refrigerators and those with flush water-sealed toilets.

    The percentage of urban households with refrigerators with respect to total urban households is projected to 1975, if the 1975 census is not available. An increase of 1 to 4 percent per annum is applied, depending upon the recent economic and social development in the city/municipality. The same procedure is applied to the percentage of urban households using flush water-sealed toilets. Table MM 3-1 shows the percentages of households with refrigerators and those with flush toilets with respect to total urban households, with points ranging from 4 to 10.

3. 1975 Business Index

The business index is measured by the percentage of commercial establishments with respect to total urban households in 1975. One industrial establishment (data from NCSO census) is assumed to be equivalent to 10 commercial establishments (except when the 1975 census is available). An increase of 1 to 20 establishments per year is applied, depending on the recent business activities and urban development in the city/municipality. The number of urban households in 1975 is obtained by multiplying the 1975 total households (total population + average of 7 persons/household) by the 1975 percentage of urban households as derived in the methodology for 1975 urban income. The 1975 sum of commercial establishments divided by the number of 1975 urban households is the business index of the city/municipality. Table MM 3-1 shows the various levels of business index, with corresponding points ranging from 2 to 20.

4. 1980 Cost of Water

The cost of water is inferred from the probable source of additional water supply by 1980. The probable source of additional water supply is weighted according to its apparent economic viability. A spring source that is located within the 1980 service area and can flow by gravity is considered the most economical. Surface water requiring complete water treatment with impounding reservoir is the most expensive. Infiltration galleries with short or long transmission lines, wells, or spring source requiring booster pump, are considered to have weights between the most and least expensive (see Table MM 3-1).

5. Served Population in 1980

The served population in 1980 is projected by delineating the future service areas of the WD and projecting the population of the city/municipality and of the service areas. The 1980 served population is determined as a portion of the service area population. In projecting the population served and the future service areas, economic growth and urban development, availability of water supply and capability of the water district to provide service must be considered.

C. Expected Water Demand By Class of WD

The experience of the LWUA-CDM staff, especially during the First Ten Urban Areas Project in the Philippines, has been used to assign values of expected water demand to the 5 classes of water districts. These expected water demands are shown in Table MM 3-2.

D. Example of Water District Classification

This method of classifying a water district is illustrated, with the Silay City Water District as an example. Available data for Silay City are taken from the NCSO and BIR reports, and from the preliminary hydro-survey by LWUA and the SIL-WD. The following data were obtained:

Total income taxes paid in the city - ₱20,049,139 (1974-1975)

Total population in the city - 103,493 (1975)

Total number of households in the city - 10,915 (1970)

Total number of households in the urban area - 3,693 (1970)

Total number of commercial establishments in the city - 36 (1970)

Total number of industrial establishments in the city - 1 (1970)

Total urban households with refrigerators - 266 (1970)

Total urban households using flush water-sealed toilets - 807 (1970)

Probable source of additional water supply - wells (1980)

Population in the service area - 21,280 (1980)

To determine the specific weights of the above data for each grouping criterion, the methodology developed is applied as follows:

TABLE MM 3-2

WATER DEMAND OF WATER DISTRICT GROUPINGS

Classification	Year 1980	Year 1990	Year 2000
Group I			
Domestic use, lpcd	140	155	175
Commercial/Industrial/Institutional			
% of domestic	17	21	20
Equivalent, lpcd	24	33	35
Accounted-for-water, lpcd	164	188	210
Unaccounted-for-water			
% of production	40	28	20
Equivalent, lpcd	109	73	52
Total production required, lpcd	273	261	262
Group II			
Domestic use, lpcd	120	135	150
Commercial/Industrial/Institutional			
% of domestic	15	17	20
Equivalent, lpcd	18	23	30
Accounted-for-water, lpcd	138	158	180
Unaccounted-for-water			
% of production	40	28	20
Equivalent, lpcd	92	62	45
Total production required, lpcd	230	220	225
Group III			
Domestic use, lpcd	105	120	135
Commercial/Industrial/Institutional			
% of domestic	13	16	18
Equivalent, lpcd	14	19	24
Accounted-for-water, lpcd	119	139	159
Unaccounted-for-water			
% of production	40	28	20
Equivalent, lpcd	79	54	40
Total production required, lpcd	198	193	199

TABLE MM 3-2 (Continued)

WATER DEMAND OF WATER DISTRICT GROUPINGS

Classification	Year 1980	1990	2000
Group IV			
Domestic use, lpcd	95	110	125
Commercial/Industrial/Institutional			
% of domestic	12	14	16
Equivalent, lpcd	12	15	20
Accounted-for-water, lpcd	107	125	145
Unaccounted-for-water			
% of production	40	28	20
Equivalent, lpcd	71	49	36
Total production required, lpcd	178	174	181
Group V			
Domestic use, lpcd	90	100	110
Commercial/Industrial/Institutional			
% of domestic	10	13	15
Equivalent, lpcd	9	13	17
Accounted-for-water, lpcd	99	113	127
Unaccounted-for-water			
% of production	40	28	20
Equivalent, lpcd	66	44	32
Total production required, lpcd	165	157	159

1. 1975 Urban Income

In 1970, the urban households accounted for 33.8 percent of the total households in the city. But due to recent developments in the local economy and subdivision housing projects in the urban sector of the city, the number of urban households was projected to increase to 35 percent in 1975. The product of the total 1974-1975 income taxes and the 1975 percentage of urban households represents the urban income taxes which amount to about ₱7.017 million. Table MM 3-1 gives this a weight of 16 points.

2. 1975 Standard of Living

This is measured by:

a. 1975 urban households using refrigerators

In 1970, 7.2 percent of the urban households had refrigerators. Due to economic and housing developments, the percentage was estimated to increase to about 12 percent in 1975. Table MM 3-1 gives this a weight of 6 points.

b. 1975 urban households using flush water-sealed toilet facilities

In 1970, the households with toilet facilities represented 21.9 percent of urban households. Due to the recent housing developments in the urban area, the households with toilet facilities were projected to be about 32 percent in 1975. Table MM 3-1 gives this a weight of 7 points.

3. 1975 Business Index

It is assumed that one industrial establishment is equivalent to 10 commercial establishments. Based on the 1970 census, the number of commercial establishments (equivalent industrial establishments included) was 46 (36 + 10). These establishments were expected to have increased to 96 (at 10 establishments per year) in 1975. Total urban households increased from 3,693 in 1970 to about 5,180 in 1975 (1975 population of 103,493 ÷ average 7 persons/household). Hence, the business index in 1975 was 1.9 percent (commercial establishments divided by the number of urban households in 1975). Table MM 3-1 gives this a weight of 7 points.

4. 1980 Cost of Water

Based on the hydro-survey of LWUA-CDM and SIL-WD, deepwells appear to be the most probable economical source of additional supply. Table MM 3-1 gives a weight of 11 points for this source.

5. 1980 Served Population

By 1980, the served population is expected to be about 15,630[1] as projected from the 1975 NCSO Census of Population and Housing. Table MM 3-1 gives this a weight of 7 points.

Therefore, the SIL-WD has a total of 54 points under the 5 criteria, indicating that it belongs to Group III. The water demands of this group from 1980 to year 2000 are listed in Table MM 3-2.

Table MM 3-3 classifies 16 water districts in the Philippines according to the 5 grouping criteria.

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[1] See Chapter VI, Table VI-3, of the Silay City Feasibility Study Report.

TABLE MM 3-3

SUMMARY OF CITIES/MUNICIPALITIES SUBJECTED
TO THE WATER DISTRICT GROUPING CRITERIA

City/Municipality	1975 Urban Income (Points)	1975 Standard of Living: Urban Households with Refrigerators (Points)	1975 Standard of Living: Urban Households with Flush Toilets (Points)	1975 Business Index (Points)	1980 Cost of Water Source of Supply (Points)	1980 Served Population (Points)	Total Points	Group
Bislig, Surigao del Sur	14	6	7	11	14	7	59	3
Urdaneta, Pangasinan	6	7	9	11	11	6	50	3
Calamba, Laguna	14	9	10	7	17	6	63	2
Gapan, Nueva Ecija	6	8	9	7	11	6	47	4
Silay City	16	6	7	7	11	7	54	3
Cebu City	20	10	10	7	5	20	72	1
Davao City	16	9	9	16	11	10	71	1
Bacolod City	20	9	9	7	11	18	74	1
Zamboanga City	14	9	9	7	7	16	62	2
Digos, Davao del Sur	12	6	9	7	11	5	50	3
Bacacay, Albay	1	5	9	11	20	5	51	3
Bangued, Abra	1	6	8	7	20	6	48	4
Dalaguete, Cebu	1	5	8	4	11	5	34	5
Baybay, Leyte	10	9	8	16	9	6	58	3
Roxas City	10	9	8	16	7	6	56	3
Cotabato City	12	9	8	11	11	7	58	3
Olongapo City	18	9	10	20	11			1
Subic	4	5	6	16	11	5	47	4
San Fernando (Pampanga)	14	6	7	20	11	7	65	2
Tarlac	12	8	8	16	11	8	63	2
Cabanatuan City	12	8	10	11	11	9	61	2
Lipa City	8	8	10	16	11	7	60	2
Lucena-Pagbilao-Tayabas	14	6	8	7	17	12	64	2
Daet	10	5	4	4	20	10	53	3

Methodology Memorandum No. 4

To : L. V. Gutierrez, Jr.

From : E. Jacildo

Date : 20 January 1977

Subject: Probability Analysis of Stream Flows by Gumbel

A. Need

In evaluating the surface water sources for water supply purposes, the analyst has to focus his interest on statistical frequency of extreme low flows. Since the exact sequence of streamflow for future years can not be predicted, he also has to consider the probable variations in flows in order to develop a design on the basis of calculated risk.

In 1941, E. J. Gumbel devised a probability method by which recurring flows can be computed for design requirements. Under this method, the hydrologic data are analyzed as an "extreme value" distribution and the sets of hydrologic data are plotted as straight lines. Gumbel's method has been found advantageous to use.

B. Basic Data

The hydrologic data are found in Surface Water Supply Bulletins published by the Water Resources Division of the Bureau of Public Works (BPW). Data are presented in the following sequence:

1. Name of river basin
2. Name of stream
3. Location of gaging station in latitude and longitude
4. Drainage area in square kilometers
5. Records available: months and year
6. Gage elevation
7. Extremes; magnitude and dates of maximum and minimum flows
8. Remarks
9. Revisions
10. Presentation of daily discharge for one year

It should be noted that <u>Surface Water Supply Bulletins</u> after 1967 have not been published; they are on file at the BPW Water Resources Division.

C. <u>Methodology</u>

Below are the steps in Gumbel's probability analysis of streamflows.

<u>Table MM4-1</u>

1. Tabulate the monthly flows (mean, minimum or maximum, whatever is desired).
2. Take note of any changes in the yearly records as stated under "Remarks" or "Revisions" of the Bulletin. Write them under remarks in Table MM4-1.

<u>Table MM4-2</u>

1. Arrange all monthly flows in ascending order, i.e., from lowest to highest. Any flow that occurs more than once should be listed.
2. Rank the arranged flows under "m".
3. Take the logarithm of Q.
4. Solve for the probability flow by the formula

$$\frac{m}{n+1} \times 100$$

   where, m is the rank of a particular flow
   n is the total number of recorded flows.
5. Solve for the return period by the formula

$$\frac{n+1}{m}.$$

<u>Figure MM4-1</u>

1. Plot log Q as ordinate against probability as abscissa. Figure MM4-1 is Gumbel's special probability paper.
2. Draw a straight line (month line) passing through the points marked in step C-1. If not all the points fall on the line, adjust the line such that it passes on the average path of the points. Any return period which falls on the line is in month's term. The line may be extended in order to reach periods not covered by it.
3. Take the antilogarithms of the values of return periods in months as projected on the log Q scale (ordinate). The antilogs are the recurring flows in cubic meters per day.

TABLE MM4-1

MEAN-DAY DISCHARGE PER MONTH

Basin:	Pampanga (San Vicente)	Gage Elevation:	11,050 m
Station:	Peñaranda River	Units:	cumd x 1,000
Location:	lat. 15°18'46"; long. 120°56'30"		
Drainage Area:	575 sqkm		

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Minimum-Day Discharge/ Year	Remarks
1965	-	2,283	753	351	372	1,313	-	-	-	3,239	5,156	4,358		
1966	-	2,915	-	-	8,941	1,595	2,682	4,215	5,425	1,413	9,801	5,3[illegible]0		
1967	4,922	857	1,189	547	873	425	1,012	6,614	4,415	5,707	5,896	125		
1968	66	77	120	540	96	-	-	-	-	-	-	117		
1969	141	32	336	689	664	301	3,203	2,394	2,248	1,175	1,785	2,190		
1970	1,989	814	279	17	17	3,561	2,928	1,628	9,590	11,726	9,689	6,915		
1971	3,123	642	732	294	1,499	4,567	4,021	1,824	1,377	11,161	5,229	15,007		
1972	5,992	4,873	406	1,461	767	415	18,347	15,977	6,306	216	4,701	2,896		
1973	697	823	82	108	95	686	2,525	2,650	4,405	14,582	4,149	2,124		
1974	1,405	1,332	2,191	471	621	3,781	3,497	10,761	10,014	12,567	16,317	13,693		

TABLE MM4-2

MEANFLOW (PEÑARANDA RIVER, SAN VICENTE)
GAPAN WATER DISTRICT

m	Q cumd x 10^3	Log Q	Probability $(\frac{m}{n+1} \times 100)$	Return Period (Months) $(\frac{n+1}{m})$
1	17	4.230	0.93	108.00
2	17	4.230	1.85	54.00
3	32	4.505	2.78	36.00
4	66	4.820	3.70	27.00
5	77	4.886	4.63	21.60
6	82	4.914	5.56	18.00
7	95	4.978	6.48	15.43
8	96	4.982	7.41	13.50
9	108	5.033	8.33	12.00
10	117	5.068	9.26	10.80
11	120	5.079	10.18	9.82
12	125	5.097	11.11	9.00
13	141	5.149	12.04	8.31
14	216	5.334	12.96	7.71
15	279	5.446	13.89	7.20
16	294	5.468	14.82	6.75
17	301	5.478	15.74	6.35
18	336	5.526	16.67	6.00
19	351	5.545	17.59	5.68
20	372	5.570	18.52	5.40
21	406	5.608	19.44	5.14
22	415	5.618	20.37	4.91
23	425	5.628	21.30	4.70
24	471	5.673	22.22	4.50
25	540	5.732	23.15	4.32
26	547	5.738	24.07	4.15
27	621	5.793	25.00	4.00
28	642	5.808	25.93	3.86
29	664	5.822	26,85	3.72
30	686	5.836	27.78	3.60
31	689	5.838	28.70	3.48
32	697	5.843	29.63	3.38
33	732	5.864	30.56	3.27
34	753	5.877	31.48	3.18
35	767	5.885	32.41	3.08
36	814	5.911	33.33	3.00
37	823	5.915	34.26	2.92
38	857	5.933	35.18	2.84

TABLE MM4-2 (continued)

MEANFLOW (PEÑARANDA RIVER, SAN VICENTE)
GAPAN WATER DISTRICT

m	Q cumd x 10^3	Log Q	Probability $(\frac{m}{n+1} \times 100)$	Return Period (Months) $(\frac{n+1}{m})$
39	873	5.941	36.11	2.77
40	1,012	6.005	37.04	2.70
41	1,175	6.070	37.96	2.63
42	1,189	6.075	38.889	2.57
43	1,313	6.118	39.815	2.51
44	1,332	6.124	40.741	2.45
45	1,377	6.139	41.667	2.40
46	1,405	6.148	42.592	2.35
47	1,413	6.150	43.518	2.30
48	1,461	6.165	44.444	2.25
49	1,499	6.176	45.370	2.20
50	1,595	6.203	46.296	2.16
51	1,628	6.212	47.222	2.12
52	1,785	6.252	48.148	2.08
53	1,824	6.261	49.074	2.04
54	1,989	6.299	50.000	2.00
55	2,124	6.327	50.926	1.96
56	2,190	6.340	51.852	1.93
57	2,191	6.341	52.778	1.89
58	2,248	6.352	53.704	1.86
59	2,283	6.358	54.630	1.83
60	2,394	6.379	55.555	1.80
61	2,525	6.402	56.481	1.77
62	2,650	6.423	57.407	1.74
63	2,680	6.428	58.333	1.71
64	2,896	6.462	59.259	1.69
65	2,915	6.465	60.185	1.66
66	2,928	6.466	61.111	1.64
67	3,123	6.494	62.037	1.61
68	3,203	6.506	62.963	1.59
69	3,209	6.510	63.889	1.56
70	3,497	6.544	64.815	1.54
71	3,561	6.552	65.741	1.52
72	3,781	6.578	66.667	1.50
73	4,021	6.604	67.592	1.48
74	4,149	6.618	68.518	1.46
75	4,215	6.625	69.444	1.44
76	4,358	6.639	70.370	1.42

TABLE MM4-2 (continued)

MEANFLOW (PEÑARANDA RIVER, SAN VICENTE)
GAPAN WATER DISTRICT

m	Q cumd x 10^3	Log Q	Probability ($\frac{m}{n+1}$ x 100)	Return Period (Months) ($\frac{n+1}{m}$)
77	4,405	6.644	71.296	1.40
78	4,415	6.645	72.222	1.38
79	4,567	6.660	73.148	1,37
80	4.701	6.672	74.074	1.35
81	4,873	6.688	75.000	1.33
82	4,922	6.697	75.926	1.32
83	5,156	6.712	76.852	1.30
84	5,229	6.718	77.778	1.28
85	5,380	6.731	78.704	1.27
86	5,425	6.734	79.630	1.26
87	5,707	6.756	80.556	1.24
88	5,896	6.770	81.481	1.23
89	5,992	6.778	82.407	1.21
90	6,306	6.800	83.333	1.20
91	6,614	6.820	84.259	1.19
92	6,915	6.840	85.185	1.17
93	8,941	6.951	86.111	1.16
94	9,590	6.982	87.037	1.15
95	9,689	6.986	87.963	1.14
96	9,801	6.991	88.889	1.12
97	10,014	7.001	89.815	1.11
98	10,761	7.032	90.741	1.10
99	11,161	7.048	91.667	1.09
100	11,726	7.069	92.592	1.08
101	12,567	7.099	93.518	1.07
102	13,693	7.136	94.444	1.06
103	14,582	7.164	95.370	1.05
104	15,007	7.176	96.296	1.04
105	15,977	7.203	97.222	1.03
106	16,317	7.213	98.148	1.02
107	18,347	7.264	99.074	1.01

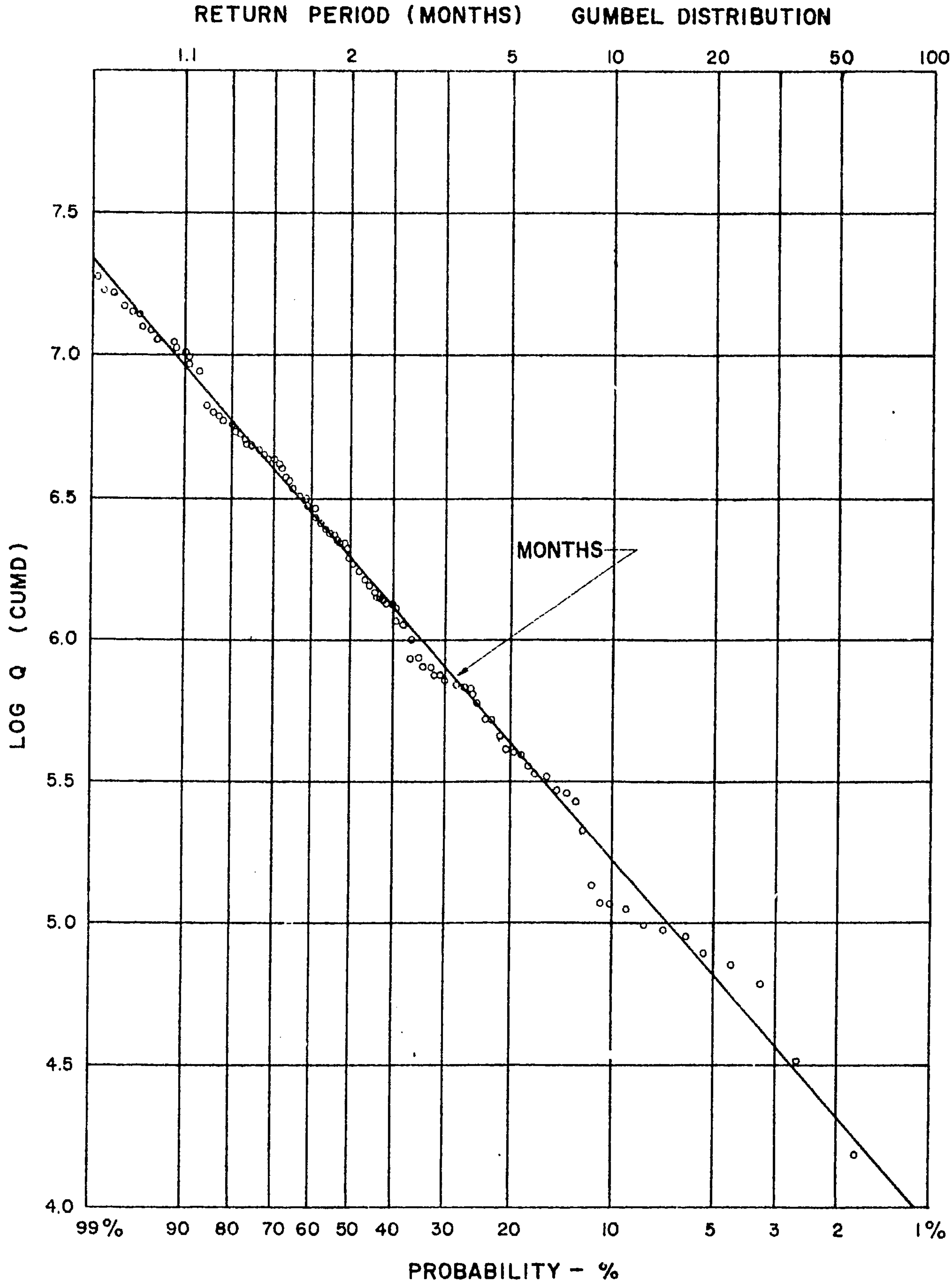

FIGURE MM4-1
MONTHLY MEANFLOW
(PENARANDA RIVER, SAN VICENTE)
GAPAN WATER DISTRICT

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

Methodology Memorandum No. 5

To : L. V. Gutierrez, Jr.

From : J. B. Arbuthnot/B. R. Conklin

Date : 16 May 1977

Subject: Quantity of Storage Versus Rate of Supply

A. General

The demand for water in a water system is not uniform, therefore, the system must be designed to supply water at varying rates of demand.

One common method of supplying water at varying rates is to provide a specific amount of source pumping capacity and supply the difference between demand and pumping capacity from a water storage facility.

The most economical amount of pumping capacity and storage volume is selected based on cost studies of alternative combinations of facilities that would meet a community's needs. Some of the factors that should be considered in these cost studies and some basic guidelines for selecting properly sized facilities are presented in this memorandum.

B. Discussion

The amount of water a community needs at any particular instant is primarily dependent on the following factors:

1. The number of people within the community
2. The number of water-consuming facilities within the average home (faucets, toilets, showers, automatic washing appliances, etc.)
3. The habits of people (what times people eat, shower, sleep, etc.)

In general, daily usage of water follows a pattern with two peak usage periods during the day and low usage late at night. Figure MM5-1 shows a typical variation measured in a section of the Cebu City distribution system.

The relationship of the peak usage on an average day can be determined statistically for a given community. The statistical peak is an average of each person's peak usage and has two important properties:

1. The statistical peak is a function of the number of people in the community. The fewer people, the higher the peak may be because each person's peak usage could more easily affect the total flow.

2. The statistical peak should be recognized as a mathematical average, and on some days the peak usage could be much higher or lower than the statistical peak.

The common engineering practice for water systems is to supply water from a source at maximum-day rates either by pumping or gravity. Maximum-day demand is the maximum quantity of water used during an entire day in a single year. Water usage can be at or near maximum-day demand for a period of weeks during summer months. Source capacity must equal maximum-day demand because it would be impractical to store sufficient water to supply maximum-day demand rates for more than a few days.

The difference in demand between the peak-hour demands and the supply (which is equal to maximum-day demands) occurs during a period of short duration where demand exceeds supply. Stored water is used to meet this short period of excess demand and is called operational storage. It should be noted at this time that there are three categories of storage:

1. Operational storage - used to meet hourly fluctuations in demand.

2. Emergency storage - used to meet demands in case of breakdowns in source facilities; typically equal to a full day's demand.

3. Fire storage - used to meet the required volume of water used to extinguish the worst fire expected in the community.

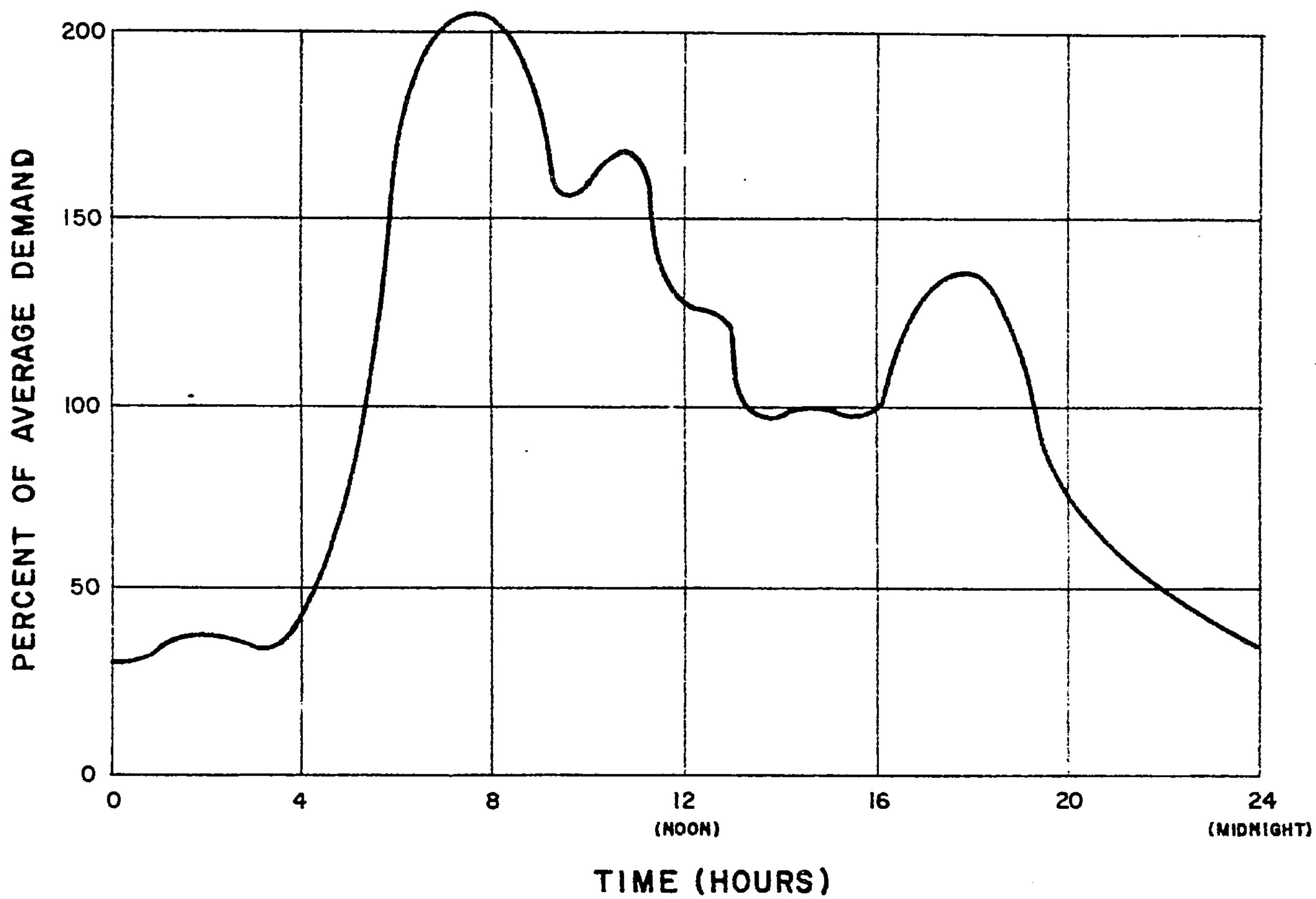

FIGURE MM5-1
DAILY USAGE PATTERN

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

Storage requirements for the last two categories have been largely neglected in these studies because of the excessive cost involved to provide the storage.

C. Methodology

The engineer must determine the amount of storage and source capacity to meet the demands in a specific community. A set of curves that relate the peak hourly usage to the number of people in a community has been developed by CDM and others.[1] Practice has shown that a volume of about 15 to 20 percent of the maximum-day usage is required as operational storage if source facilities can supply maximum-day demands. Combining the "peaking curves" with the operational storage requirement, a second set of curves relating the quantity of storage to the number of people, at different rates of source supply, has been developed (see Figure MM5-2).

Up to this point, the only option that has been discussed is to supply peak-hour demands from storage facilities. In many cases, the cost of storage facilities is so high that it may be more economical to provide additional source capacity and reduce the quantity of storage. This is especially true where storage is provided in elevated structures that are very costly, since they are built to withstand earthquakes. The curves in Figure MM5-2 have been used in this study to determine the requirements for storage at various supply rates in order to prepare cost comparisons of alternative supply and storage combinations.

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[1] ASCE Manual of Practice No. 37.

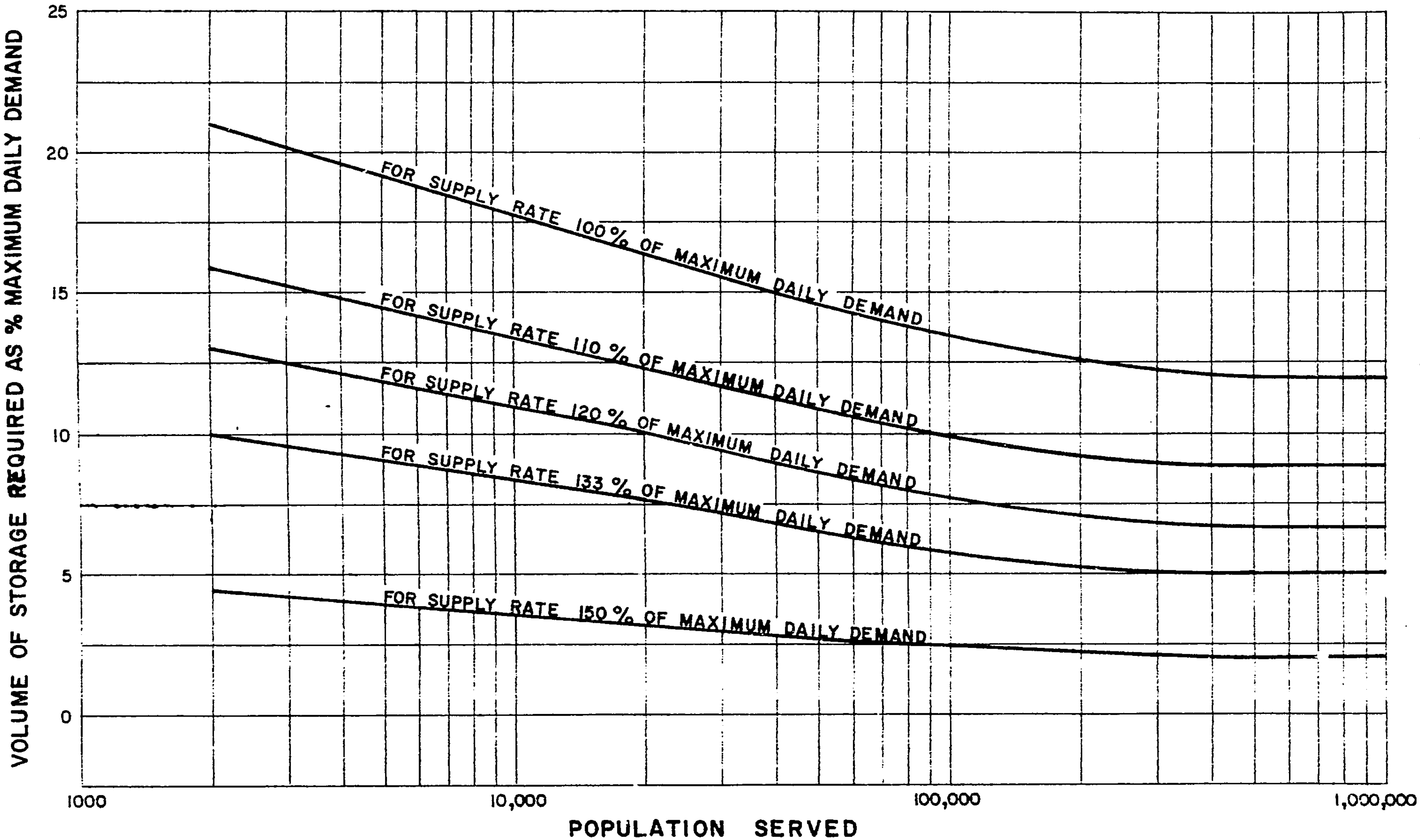

FIGURE MM 5-2
STORAGE REQUIRED TO MEET DAILY PEAK WATER DEMAND

Methodology Memorandum No. 6

To : L. V. Gutierrez, Jr.

From : J. Arbuthnot; B. Conklin

Date : 22 March 1977

Subject: Economical Sizing of Pumped Waterlines

A. General

This memorandum develops an expression for the most economic size of a pipeline for pumped water systems based on two cost factors: cost of pipe-in-place and cost of pumping (energy). The larger the pipe the greater the cost of construction. Also, the larger the pipe the lesser the cost of energy required to pump water through the pipe. The most economic pipe sizes would be where the incremental cost of pumping is equal to the incremental cost of pipe construction.

In most situations, the above cost factors are the most important factors in determining the economical size of transmission mains. Even when these are not the only important factors, it is still advantageous to know what is the most economic size of pipe with regard to these two factors.

B. General Relationship

The total annual cost of a pipe line is equal to the sum of its construction cost (expressed on an amortized annual basis) plus its annual pumping cost.

$$C_t = C_c + C_p \text{ [1]}$$

To determine the most economic pipe diameter both the factors on the right hand side of the equation were expressed in terms of the diameter of the pipe. The equation was then differentiated with respect to the diameter, and solved for the diameter for which the resulting expression was equal to zero.[2]

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[1] Total Annual Cost = Annual Construction Cost + Annual Pumping Cost.

[2] $\frac{d(C_t)}{dx} = \frac{d(C_c)}{dx} + \frac{d(C_p)}{dx} = 0$, where X = pipe diameter

C. Annual Construction Cost

The construction cost of the pipe was taken from Table G-4 of Appendix G, Basis of Cost Estimates, in Volume II of the final report. Costs were adjusted by adding a value for necessary valves and by escalating these by 10 percent per year for 2 years to obtain July 1978 construction costs. These costs were then increased by 15 percent for contingencies and then by 10 percent for engineering. The following equation was derived and represents the adjusted construction costs in Table G-4 in terms of the diameter.

$$C = 2845\,(\text{Dia.})^{1.292} \quad \text{- - - - Equation 1}$$

C is the installed cost of pipe in pesos per meter, and Dia, the diameter of the pipe in meters.

The amortized annual cost of construction is the cost of construction multiplied by the capital recovery factor (as influenced by the economic life of the pipe and discount factor). The general equation is:

$$\text{Annual Cost of Construction} = \text{CRF} \times 2845(\text{Dia.})^{1.292} \quad \text{- - - - Equation 2}$$

where CRF is the capital recovery factor; for n = 50 years, discount rate = 12%, CRF is equal to 0.12042.

D. Annual Pumping Cost

The annual cost of pumping energy may be expressed in terms of the amount of water pumped, the energy required to overcome the frictional loss in the pipe, the price of electrical energy and the efficiency of the pumping machinery. The general equation may be written as:

$$\text{Annual Cost of Pumping Energy} = \frac{\text{Mass/Year} \times g \times \text{Hf} \times ₱/\text{kwh}}{\text{efficiency} \times 3.6 \times 10^{6}} \quad \text{- - - - Equation 3}$$

where mass/Year is the amount of water pumped in kilograms; g, the gravitational constant; Hf, the energy lost by friction of flow in the pipe expressed in meters; ₱/kwh, the cost of energy in pesos per kilowatt hour; and 3.6×10^{6}, the number of newton-meters per kilowatt hour.

The friction loss of energy in the pipe may be expressed in terms of the diameter utilizing the Hazen-Williams (H&W) equation,

$$\text{Hf} = \frac{\text{L} \times \text{MLD}^{1.852}}{361.27\ C^{1.852}\ D^{4.87}} \quad \text{- - - - Equation 4}$$

where L is the length of pipe in meters; MLD, the flow of water in million liters per day; C, the Hazen & Williams roughness coefficient; and Dia, the diameter of the pipe in meters.

. **Minimum Cost Diameter**

The expression for minimum cost diameter may be obtained by inserting the expression for Hf in the equation for the cost of pumping energy, combining this with the expression for the annual cost of construction, differentiating, setting the resulting expression equal to zero and solving for the diameter:

$$\text{Minimum Cost Diameter} = \frac{MLD^{0.4628} \times (\text{pesos/kwh})^{0.1623}}{2.391\ (\text{efficiency})^{0.1623}\ C^{0.3005}\ (A/P,\ X\%,\ n)^{0.1623}}$$

using a C value of 120 and a capital recovery factor of 0.12042, the following equation is obtained:

$$\text{Minimum Cost Diameter} = \frac{MLD^{0.4628}(\text{pesos/kwh})^{0.1623}}{7.149\ (\text{efficiency})^{0.1623}} \text{ - - - - Equation 5}$$

The above equation is expressed graphically in Figure MM 6-1.

. **Limitations of the Analysis**

How reliable is the preceding relationship (Equation 5), between water carried and economic pipe diameter? The derivation is rigorous but the relation is no more exact than are the simplifying assumptions upon which the derivation was based:

1. Construction Cost Relationship

The construction cost relation (Equation 1) has a standard deviation of just under 10 percent. This means that two-thirds of the time the formula will represent the adjusted costs tabulated, within 10 percent. The largest difference observed was 20 percent. Even so, economic conditions and the cost of pipe may change in time. Probably, a new table of pipe costs has to be made every 2 or 3 years, and the formulas, along with Figure MM 6-1, adjusted accordingly.

2. Other Assumptions

Other assumptions are:

C = 120 (Hazen & Williams coefficient)
i = 12% (Discount rate)
n = 50 years (Economical life of pipe)

The derivation also assumes that for the changes in pumping head, using various pipe sizes for a design flow, the total construction cost of the pumping station remains constant. This assumption is reasonable since the difference in cost between one pump selection and another for different heads at the same flow would not alter the cost of the complete station by significant amount. Generally, the installed motor horsepower would also be the same since the motors come in standard sizes and one size may be used for a number of different pump selections at a gi-en flow.

The relative rate of inflation for pipeline construction is assumed equal to that of power costs.

3. Flow Quantities are Based on Constant Flow

The derivation of the most economic pipe diameter is based on a constant rate of flow within the pipe. This is probably the most general and therefore the least accurate of any of the assumptions.

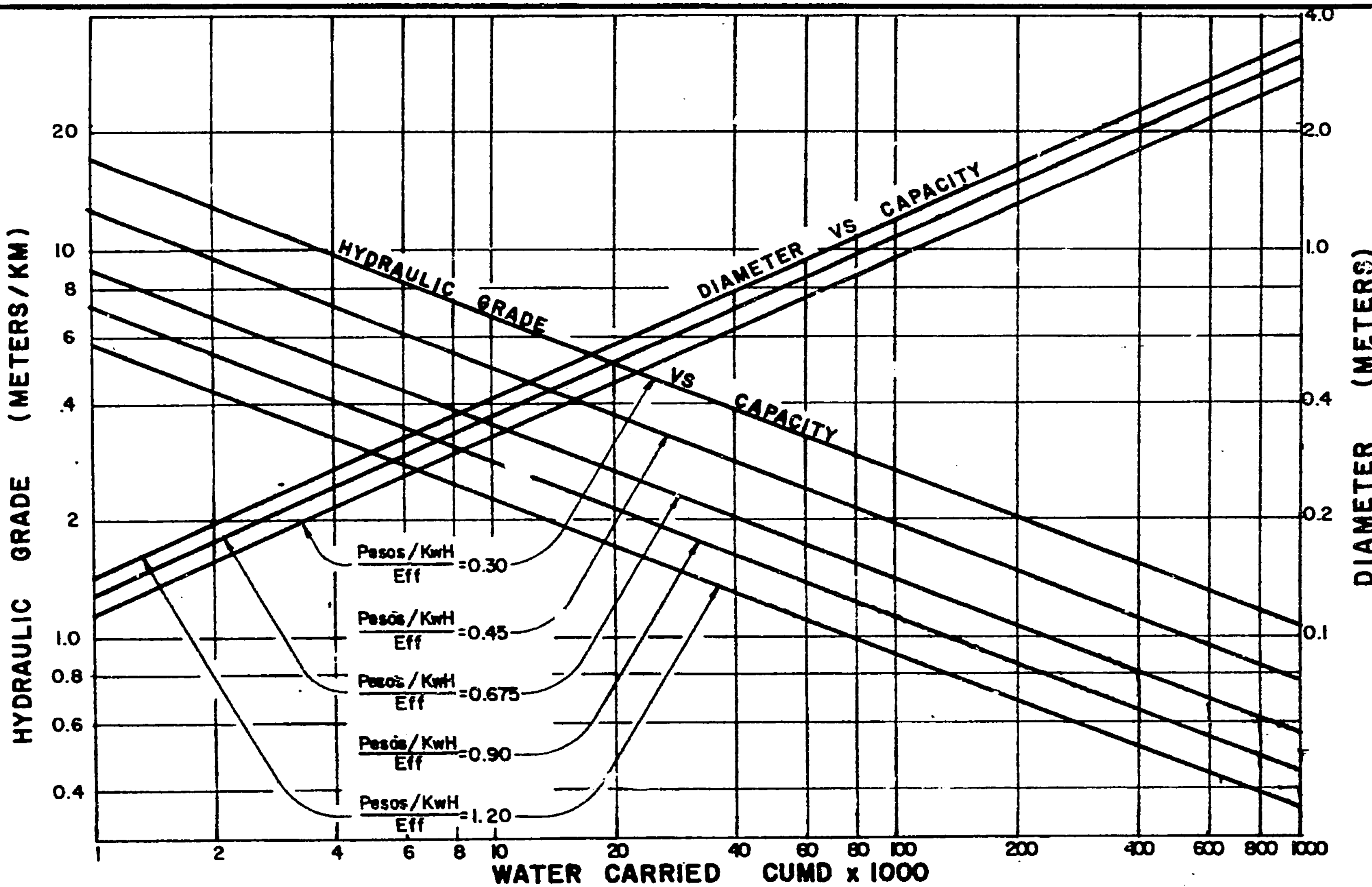
Normally a pipeline is designed for a specific flow condition; even under design conditions that flow may occur only part of the time. The flow in a transmission main could be expected to nearly equal the design flow for long period of time. However, in a distribution main, sized for peak-hour flows, the flow may not be equal to the design flow except for very short periods of time.

The variation in energy costs due to a fluctuating pumping rate through a pipeline can be calculated and applied to adjust the most economic pipe diameter determined from Figure MM 6-1. This so-called "energy variability factor" is discussed in the following section.

G. Energy Variability Factor

Figure MM 6-1 is based on selecting a pipeline where the flow will be constant throughout the year. In most cases, pipeline sizes are selected on a maximum expected rate of flow. If the flow through the pipeline is less than the design flow, the pumping head (which directly affects energy costs) would decrease according to the 2.852 power of the flow (Q). Conversely, if flow greater than design flow rate is pumped through a pipeline, the energy cost would be increased by the 2.852 power.

The overall difference in energy costs over the day or year can be calculated by comparing the costs of pumping at a constant flow rate with the cost of pumping at the expected flow variation. This value is the so-called "energy variability factor" (EVF). The design flow for the pipe is used as the base flow and the actual flow to the design flow over the day is expressed as a percent.



Note : 1. CONSIDERS CONSTRUCTION AND PIPELINE FRICTION COSTS ONLY INCLUDING ENGINEERING AND CONTINGENCIES
2. AVERAGE C = 120 OVER 50 YEARS
3. ECONOMIC DISCOUNT RATE = 12 %
4. PIPE COST (MID 1978 PRICES) = $2845D^{1.29}$ PER METER, (D IN METERS)

FIGURE MM6-1
MOST ECONOMIC WATER TRANSMISSION

The method used is to raise the difference between actual flow and the base flow (expressed as a percentage) to the 2.852 power. The ratio of the sum for the day of the actual flow to the design flow each raised to the 2.852 power is equal to the EVF. Figure MM 6-2 and Table MM 6-1 present two possible flow variations and the calculated energy variability factor for each.

The two flow patterns selected for Figure MM 6-2 are not commonly used design curves. Pattern 1 was selected to show that if a higher rate of flow than the design flow is pumped through the pipeline during a portion of the day, the EVF is greater than 1.0. Pattern 2 shows that if the actual flow rate is nearly equal to the design flow, the EVF would be nearly equal to 1.0.

An EVF of less than 1.0 would be a more common occurrence since the majority of pipelines are designed for some maximum future flow. The suggested EVF in a following section is an example of an EVF less than 1.0.

I. Application of EVF

The EVF can be used with Figure MM 6-1 in calculating the minimum cost pipe diameter. The EVF is inserted into the annual energy cost equation (equation 3) and then included in the differentiation, resulting in a revised equation as follows:

$$\text{Minimum Cost Diameter} = EVF^{0.1623} \frac{MLD^{0.4628}\ (\text{Pesos/kwh})^{0.1623}}{7.149\ (\text{efficiency})^{0.1623}} \quad \text{-- Equation 6}$$

The application of EVF requires 2 steps: first, design a minimum economic pipeline for some flow using Figure MM 6-1; and second, calculate the EVF for the actual flow variation and multiply the pipe size calculated in Step 1 by the EVF raised to the 0.1623 power.

J. Suggested EVF

The feasibility report on the Second Ten Provincial Urban Areas deals mainly with distribution pipelines; therefore, a suggested EVF that is applicable to distribution systems is presented herein.

The calculation of an EVF depends entirely on the flow data or assumed flow within a specific pipeline. The only accurate data produced during the feasibility studies are the diurnal flow variations measured in a portion of Cebu. The peak flow in the Cebu data was 2.06 which is greater than the design flows

TABLE MM 6-1

SAMPLE "EVF" FOR DIFFERENT FLOW PATTERNS

Hour	Flow Pattern No. 1: Percent of Average Day Demand	Flow Pattern No. 1: Energy Variation	Flow Pattern No. 2: Percent of Average Day Demand	Flow Pattern No. 2: Energy Variation
1	32	0.039	48	0.123
2	36	0.054	48	0.123
3	39	0.068	48	0.123
4	33	0.042	100	1.000
5	46	0.109	100	1.000
6	95	0.864	100	1.000
7	193	6.522	120	1.682
8	206	7.855	120	1.682
9	198	7.016	120	1.682
10	156	3.554	120	1.682
11	169	4.466	120	1.682
12	129	2.067	120	1.682
13	123	1.805	120	1.682
14	95	0.864	120	1.682
15	99	0.972	120	1.682
16	96	0.890	120	1.682
17	107	1.212	120	1.682
18	133	2.255	120	1.682
19	130	2.113	120	1.682
20	87	0.672	100	1.000
21	64	0.280	100	1.000
22	54	0.172	100	1.000
23	42	0.084	48	0.123
24	38	0.063	48	0.123
		44.038		28.481

$EVF_1 \frac{44.038}{24.000} = 1.83$ $EVF_2 \frac{28.481}{24.000} = 1.19$

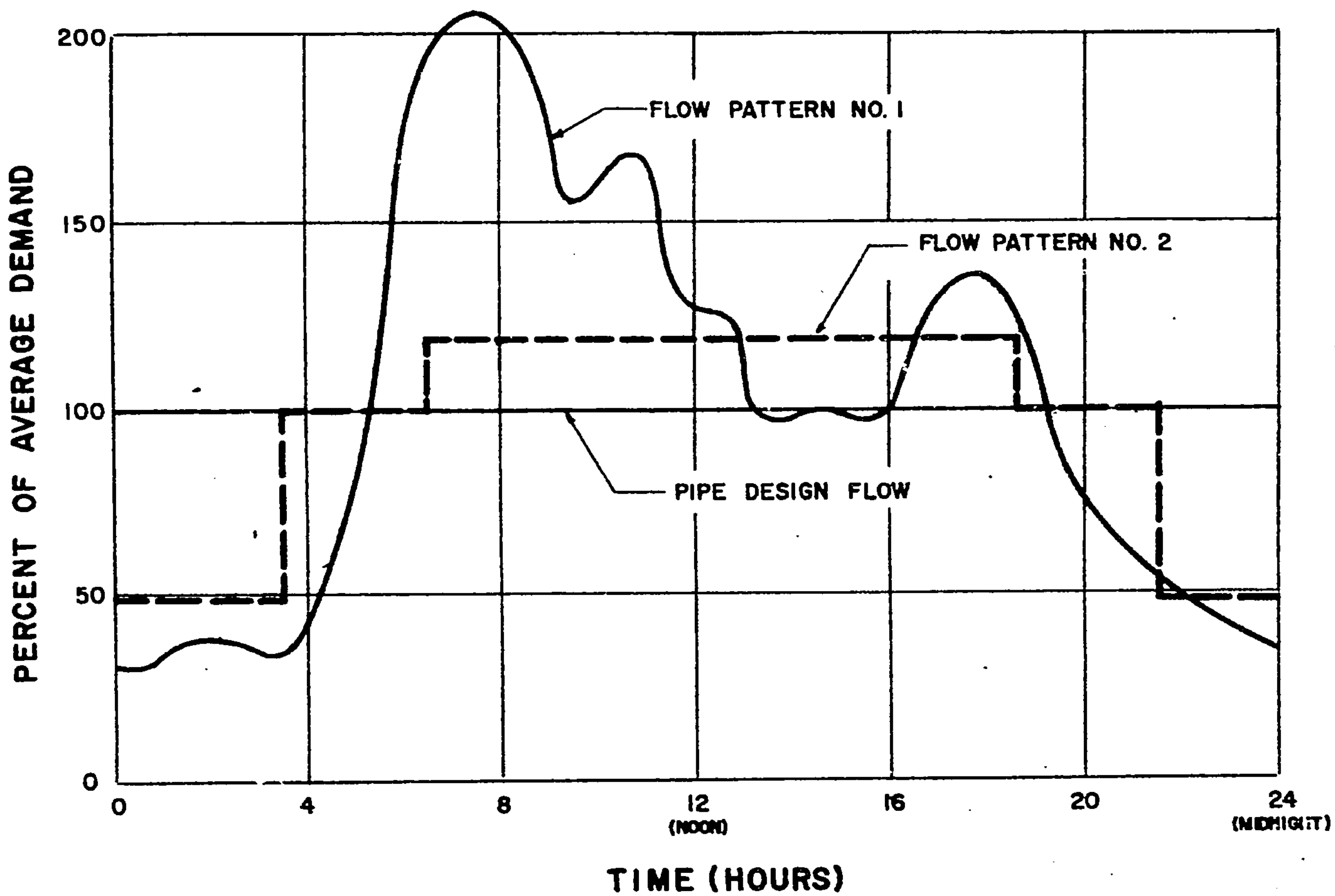


FIGURE MM6-2
SAMPLE FLOW PATTERNS

used for this study. Figure MM 6-3 presents an adjusted graph of diurnal flow using the shape of the Cebu curve but a maximum peak of 1.75. The EVF for this curve is equal to 0.32 (see Table MM 6-2) and when raised to the 0.1623 power, equals 0.83.

In practice, the EVF used for distribution systems in this study is only significant when the pipeline size is greater than 300 mm (significant means that EVF changes the recommended pipe size by a large incremental size).

Example

Problem: Select an economical distribution pipe size to convey a peak-hour flow of 20 MLD. The cost of power is 49 centavos per kilowatt hour, the pump efficiency is 81 percent, and the motor efficiency is equal to 90 percent.

Solution:

$$\frac{\text{Pesos/kwh}}{\text{Eff}} = \frac{.49}{.81 \times .90} = .672, \quad \text{say } .675$$

From Figure MM 6-1 using the flow of 20 MLD and Pesos/kwh/Eff = .675 select a pipe size of 500 mm.

For a flow variation in a distribution main, the EVF is equal to 0.32 and the EVF raised to the 0.1623 power is equal to 0.83. The most economical pipe size for the actual flow variation is equal to 0.83 x 500 m or 415 mm; so choose 400 mm pipe size.

TABLE MM 6-2

"EVF" FOR DISTRIBUTION SYSTEM

Hour	Percent of Average Day Demand	Percent of Design Flow[3]	Energy Variation[4]
1	35	20	0.010
2	40	23	0.015
3	39	22	0.013
4	37	21	0.012
5	73	42	0.084
6	134	77	0.475
7	164	94	0.838
8	175	100	1.000
9	174	99	0.972
10	163	93	0.813
11	162	93	0.813
12	134	77	0.475
13	118	67	0.317
14	94	54	0.172
15	94	54	0.172
16	94	54	0.172
17	105	60	0.233
18	129	74	0.424
19	123	70	0.362
20	96	55	0.182
21	72	41	0.079
22	58	33	0.042
73	47	27	0.024
24	40	23	0.015
			7.716

$$EVF = \frac{7.716}{24.000^{*}} = —.32 \qquad EVF^{0.1623} = 0.83$$

[3] Using 175 percent of average day as base flow for pipe design.
[4] Equals Percent Design Flow raised to the 2.852 power.
* Energy variation at constant flow

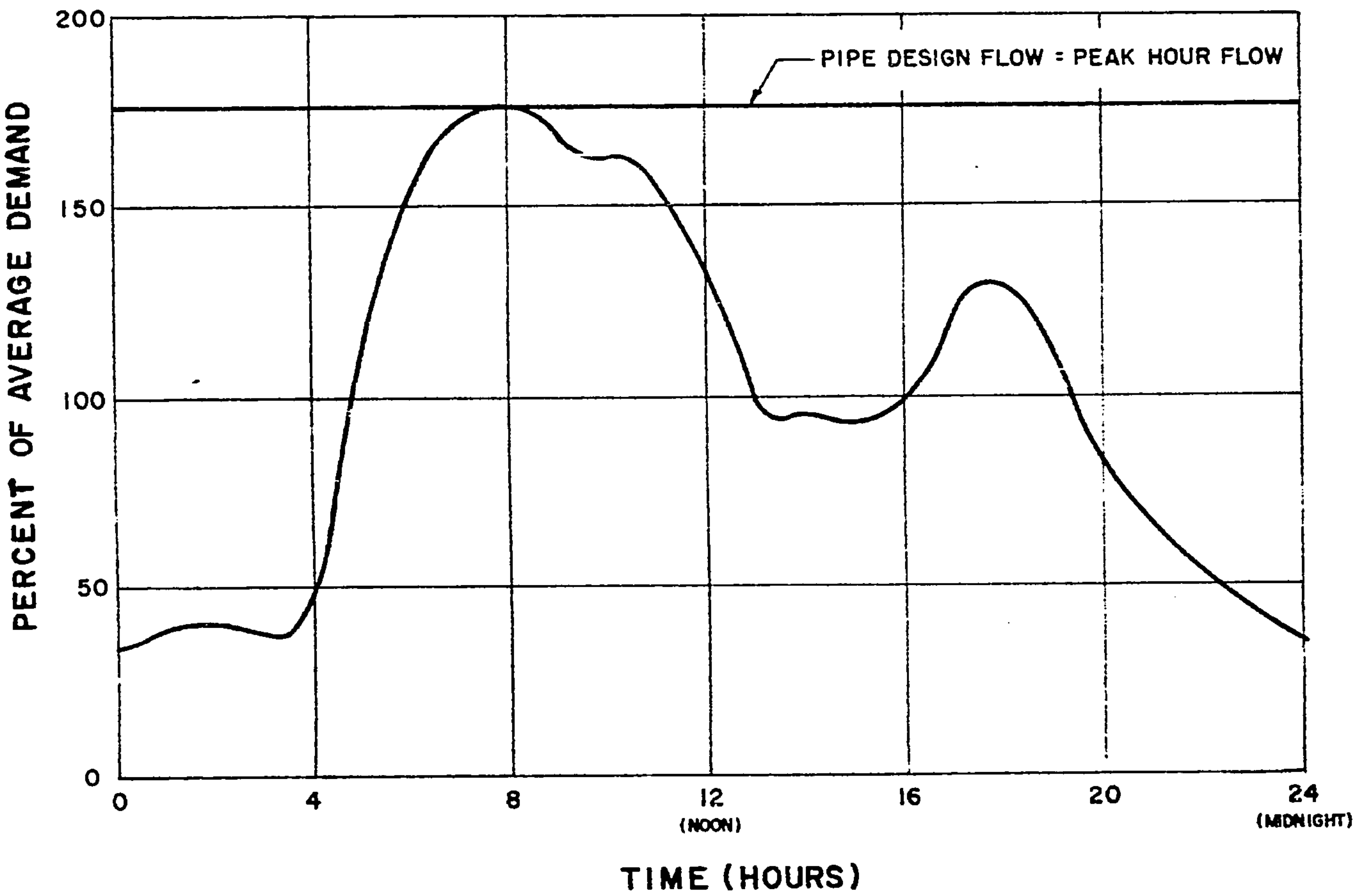
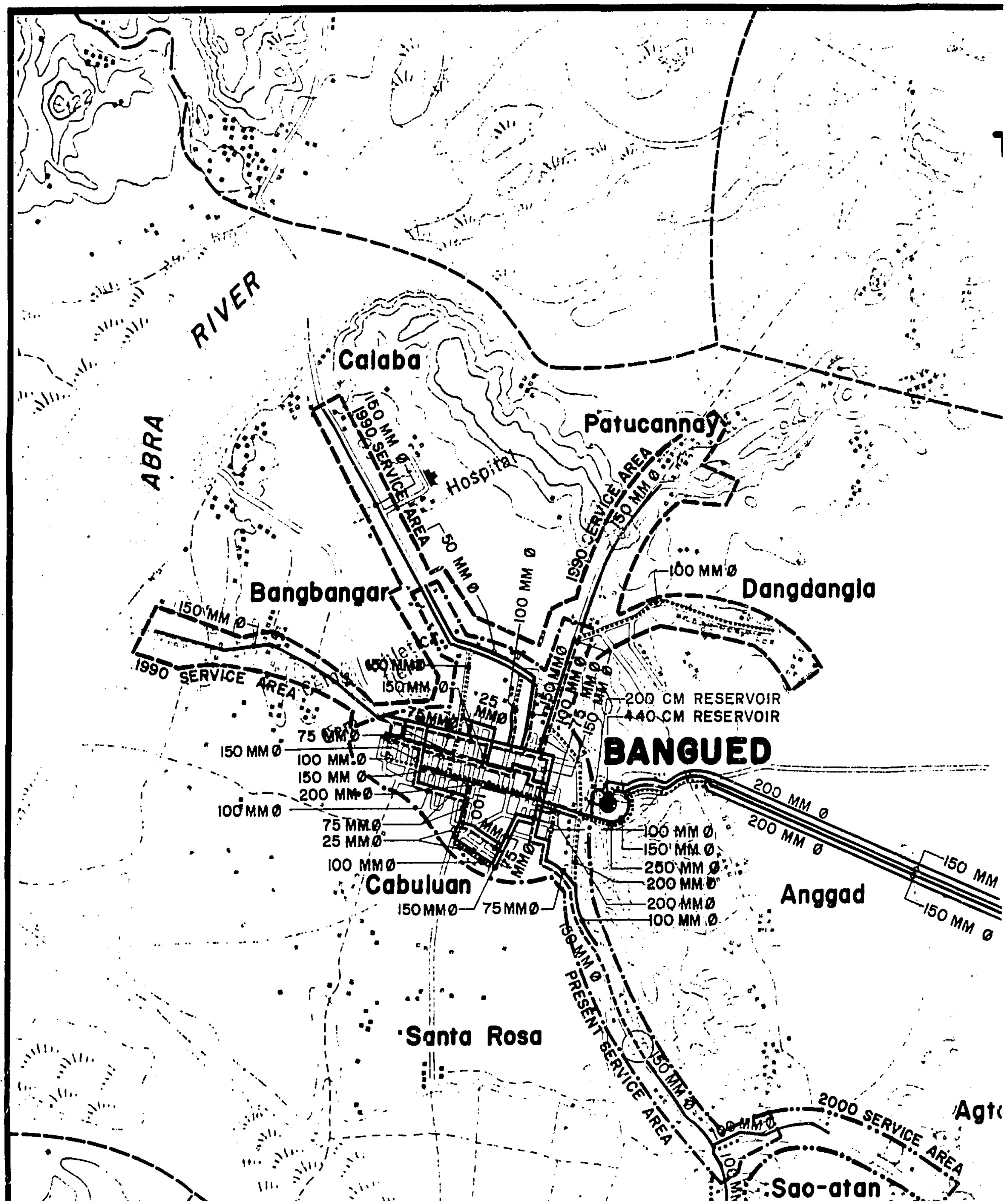
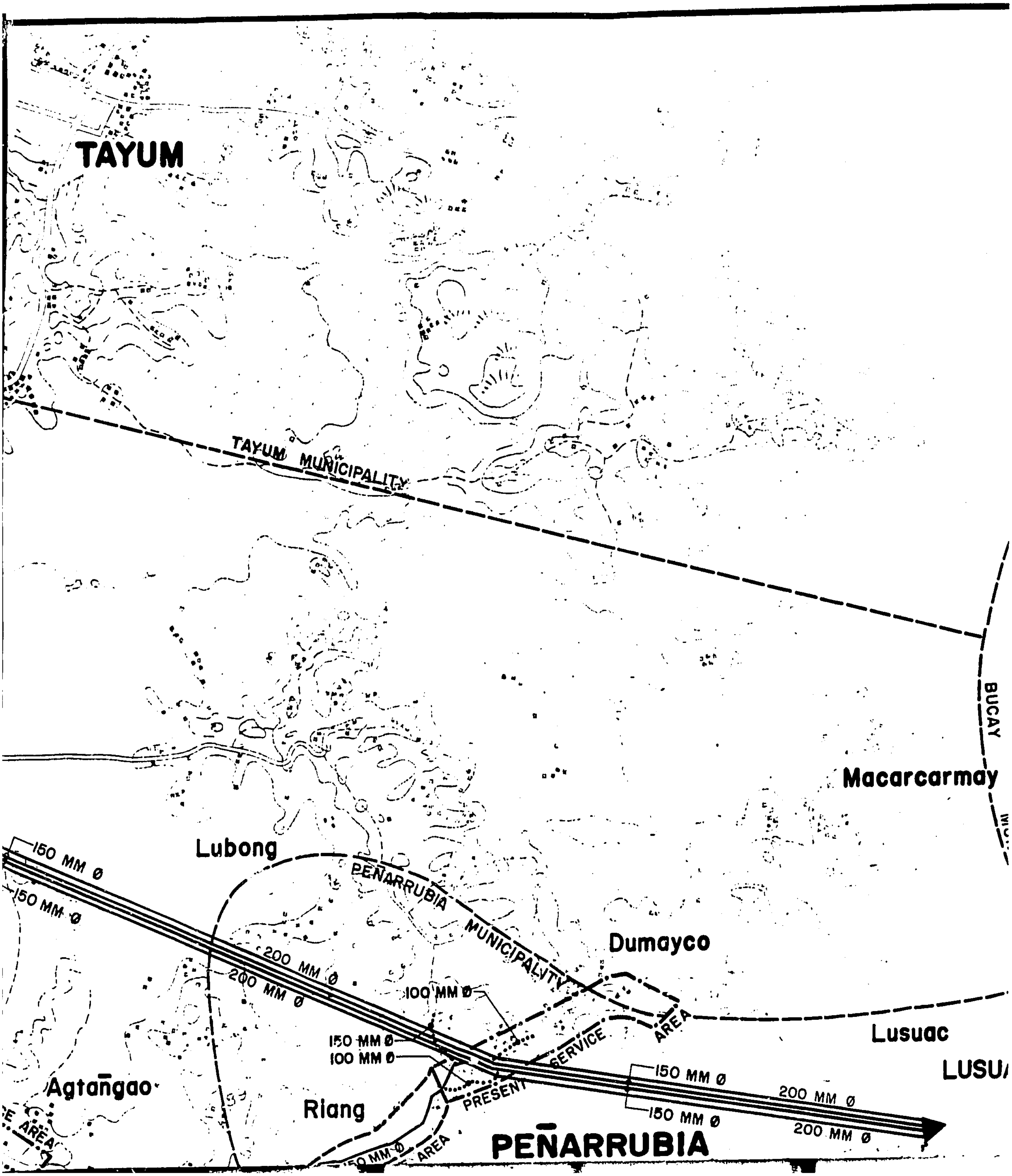
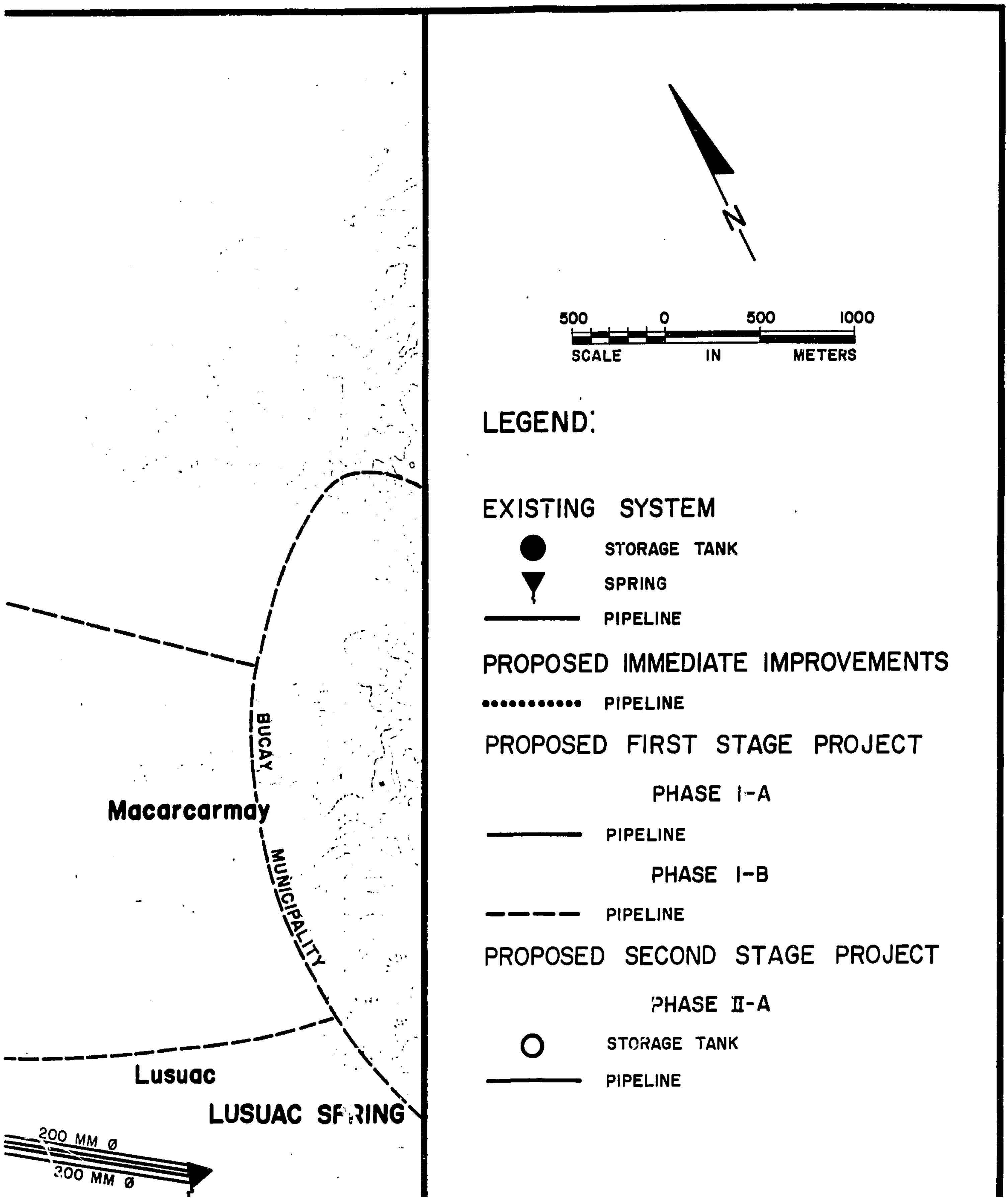
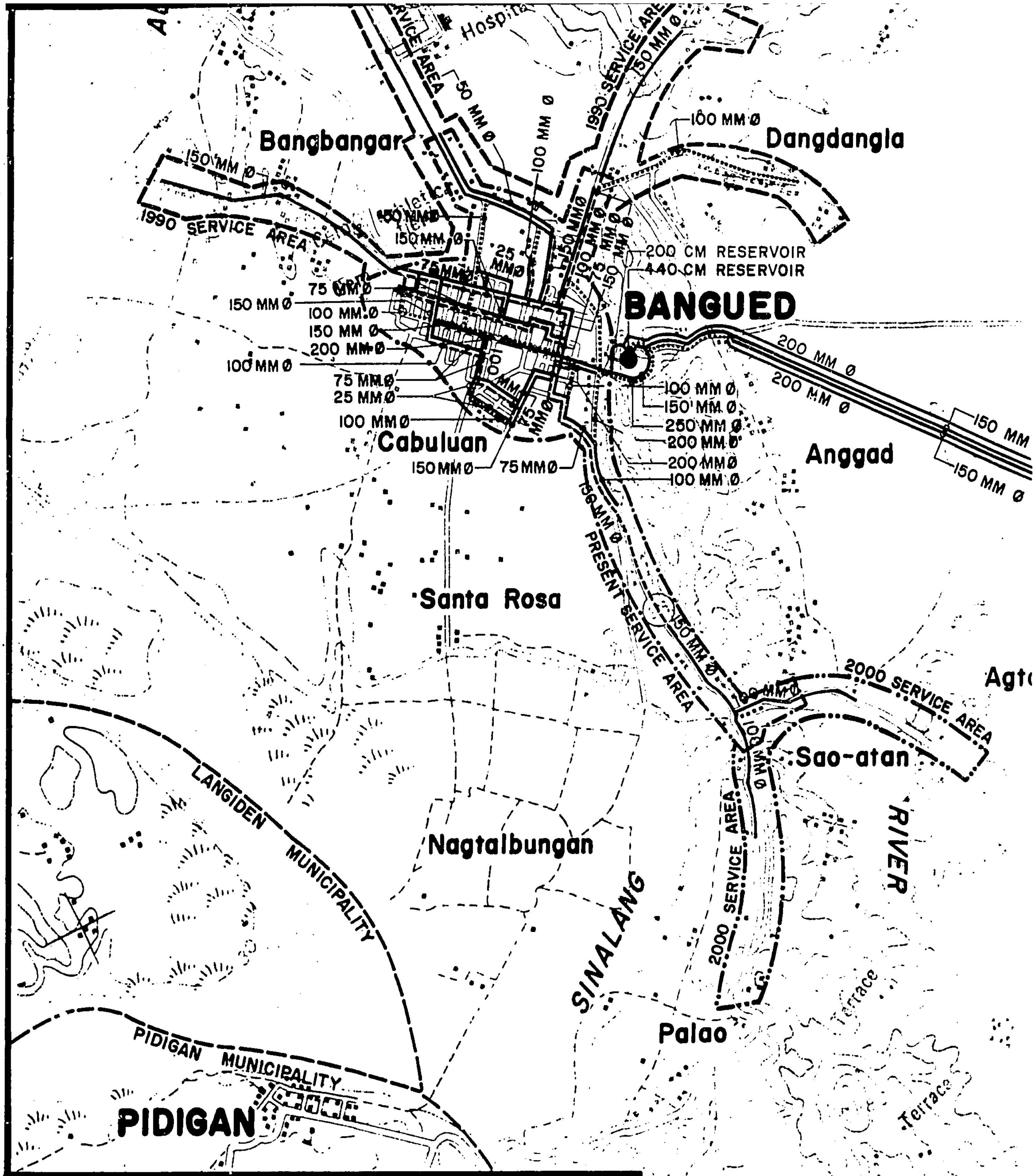


FIGURE MM6-3
TYPICAL FLOW VARIATION FOR DISTRIBUTION MAINS

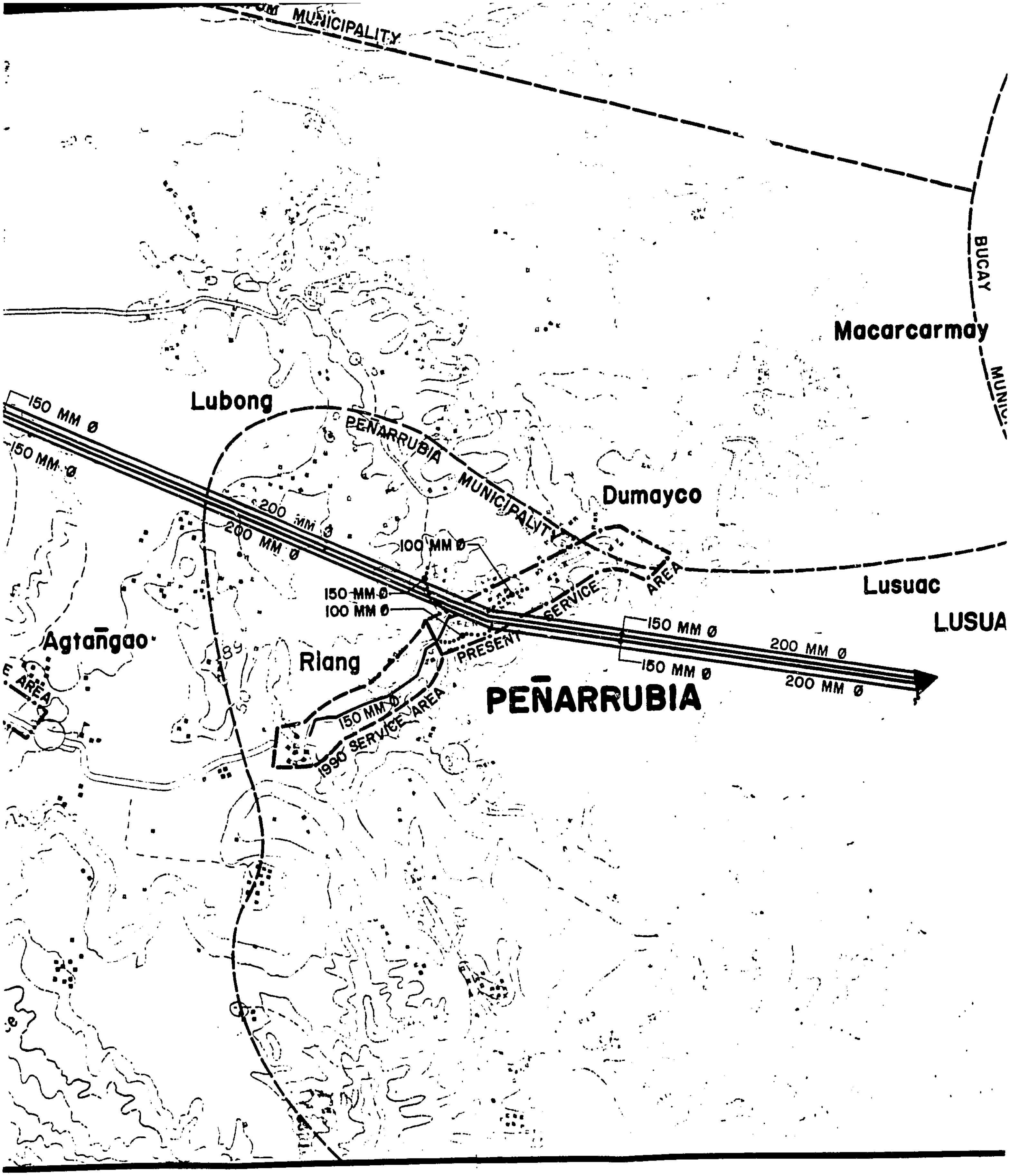

ABRA
RIVER
Calaba
Patucannay
Hospital
150 MM Ø
1990 SERVICE AREA
50 MM Ø
100 MM Ø
1990 SERVICE AREA
150 MM Ø
100 MM Ø
Bangbangar
Dangdangla
150 MM Ø
1990 SERVICE AREA
200 CM RESERVOIR
440 CM RESERVOIR
BANGUED
150 MM Ø
100 MM Ø
150 MM Ø
200 MM Ø
100 MM Ø
75 MM Ø
25 MM Ø
100 MM Ø
200 MM Ø
200 MM Ø
150 MM
150 MM Ø
100 MM Ø
150 MM Ø
250 MM Ø
200 MM Ø
200 MM Ø
100 MM Ø
Anggad
Cabuluan
150 MM Ø
75 MM Ø
150 MM Ø
PRESENT SERVICE AREA
Santa Rosa
150 MM Ø
100 MM Ø
2000 SERVICE AREA
Sao-atan


TAYUM
TAYUM MUNICIPALITY
BUCAY
Macarcarmay
Lubong
150 MM Ø
150 MM Ø
PEÑARRUBIA
MUNICIPALITY
Dumayco
200 MM Ø
200 MM Ø
100 MM Ø
AREA
Lusuac
150 MM Ø
100 MM Ø
SERVICE
PRESENT
150 MM Ø
200 MM Ø
LUSU
Agtañgao
Riang
150 MM Ø
200 MM Ø
AREA
AREA
PEÑARRUBIA

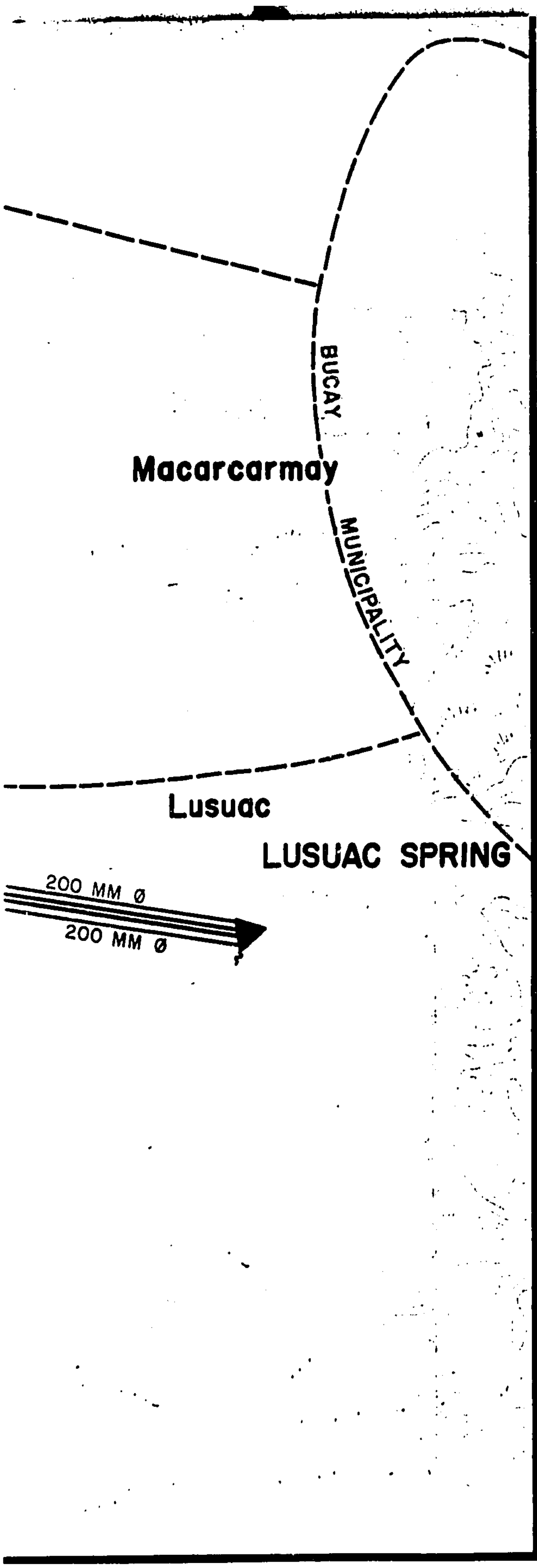

Z
500 0 500 1000
SCALE IN METERS
LEGEND:
EXISTING SYSTEM
STORAGE TANK
SPRING
PIPELINE
PROPOSED IMMEDIATE IMPROVEMENTS
PIPELINE
PROPOSED FIRST STAGE PROJECT
PHASE I-A
PIPELINE
PHASE I-B
PIPELINE
PROPOSED SECOND STAGE PROJECT
PHASE II-A
STORAGE TANK
PIPELINE
BUCAY
MUNICIPALITY
Macarcarmay
Lusuac
LUSUAC SPRING
200 MM Ø
200 MM Ø



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



MUNICIPALITY
BUCAY
Macarcarmay
MUNI
Lubong
150 MM Ø
150 MM Ø
PEÑARRUBIA
MUNICIPALITY
Dumayco
200 MM Ø
200 MM Ø
100 MM Ø
AREA
SERVICE
PRESENT
Lusuac
150 MM Ø
100 MM Ø
150 MM Ø
LUSUA
Agtañgao
Riang
200 MM Ø
150 MM Ø
200 MM Ø
AREA
PEÑARRUBIA
150 MM Ø
1990 SERVICE AREA



EXISTING SYSTEM

- STORAGE TANK
- SPRING
- PIPELINE

PROPOSED IMMEDIATE IMPROVEMENTS

- PIPELINE

PROPOSED FIRST STAGE PROJECT

PHASE I-A

- PIPELINE

PHASE I-B

- PIPELINE

PROPOSED SECOND STAGE PROJECT

PHASE II-A

- STORAGE TANK
- PIPELINE

FIGURE IX-I

WATER SUPPLY SOURCE
TRANSMISSION AND DISTRIBUTION SYSTEM
MAP SHOWING

EXISTING FACILITIES

RECOMMENDED STAGE I FACILITIES

RECOMMENDED STAGE II FACILITIES

BANGUED WATER DISTRICT