MINISTRY OF INTERIOR
PROVINCIAL WATERWORKS AUTHORITY

DEVELOPMENT PLAN AND FEASIBILITY STUDY
ON
PROVINCIAL WATER SUPPLY PROJECTS
IN
THE KINGDOM OF THAILAND

FINAL REPORT
FOR
SU NGAI GOLOK

MARCH 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to a request from the Government of Thailand, the Japanese Government decided to conduct a Feasibility Study on the Improvement of the Sewerage System in the Southern Part of Lima and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Thailand a survey team headed by Mr. Ikuo Miwa, Nippon Jogesuido Sekkei Co., Ltd., from July to October, 1988, from January to March, 1989, and from October to November, 1989.

The team held discussions with concerned officials of the Government of Thailand, and conducted field surveys. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Thailand for their close cooperation extended to the team.

March, 1990

Kensuke Yanagiya
President
Japan International Cooperation Agency

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EXECUTIVE SUMMARY

Part 1 - GENERAL

THE STUDY AREA

The Municipality of Su Ngai Golok is one of the centers of Narathiwat Province. Narathiwat is situated on the southeastern crest in the southern region of Thailand. Su Ngai Golok is a border town and enjoys commerce and tourism with Malaysia.

As the southernmost town in Thailand, Su Ngai Golok is bounded by the Golok River. The river originates from Malaysia and flows into the Gulf of Thailand with an average annual discharge of 2,000 MCM, flooding the low-laying areas during the rainy season. Alluvial deposits formed in the areas along small streams that flow into the Golok River.

Average annual rainfall in the areas is 2,600 mm while average annual pan evaporation level is 1,700 mm. Mean monthly temperature varies from 28.5 °C in April to 26.1°C in January.

In 1986, there were 9,877 people gainfully employed in rubber plantations, industrial, commercial, service and other establishments in the study area.

Tourism is a booming economic activity in the area. At present, there are 57 hotels with a total of 2,063 rooms. These are located mostly at the central commercial district of the municipality.

Land transportation is the major means of travel in the area, where two inter-city roads meet. One is Route 4056 which connects the town and Narathiwat and the other is Route 4057 which leads to Tak Bai and Waeng. Boat services across the Golok River is also an important means of daily transportation for people and commodities in the area.

The government plays a vital role in all aspects of Thailand's educational system, which is divided into three levels - primary, secondary and tertiary. There are 17 schools in Su Ngai Golok.

Existing land use shows that most commercial facilities including hotels and restaurants and high density residential areas are concentrated between Route 4056 and the Prachavivat Road. Forests including rubber plantations abound in the southwestern areas.

WATER SOURCE

Main water sources in the study area are the Golok River, shallow wells and a few deep wells.

The Golok River originates from the highland region southwest of Su Ngai Golok. The catchment area is 774 sq. km.

Rainwater collection, which is a traditional source for water supply in Thailand, is rarely utilized in the study area.

Shallow wells and deep wells are commonly used as alternative water sources in the study area, especially by private houses and institutional establishments, respectively.

Monthly rainfall data were recorded at four gauging stations in the Thai side of the catchment area of the Golok River. Climatology data area available at Narathiwat.

Hydrological data were available both at the station on the Thai side and on the Malaysian side. For hydrogeological data, the only ones available are the map prepared by the DMR, the Golok River Basin Development Study Report and the Bang Nara Irrigation and Drainage Project Feasibility Study Report.

Several methods such as rating curve plotting and gauging were used for estimating the discharge capacity of the water sources at Rantau Panjang, Mu No and Waeng.

Low flow analysis as reported in the Golok River Basin Development Study showed 2.5 cu.m/s once in 10 years, 30-day low flow.

Water demand in the target year 2011 was estimated at 0.137 cu.m/s in intake level including the intake loss. Thus, the existing and proposed water sources have sufficient flows even in the return period of 10 years.

Studies made on groundwater or alternative source for water supply showed that groundwater can be developed for private household's use but not feasible for public water supply because of unreliable quantity during the day season and contamination of source throughout the year.

EXISTING WATER SUPPLY SYSTEM

The waterworks for the municipality of Su Ngai Golok was founded in 1964. The system initially had a treatment plant with a capacity of 20 cu.m./h, treating raw water from the Golok River. In 1969, the treatment capacity was increased to 180 cu.m./h with the construction of a new 160 cu.m./h treatment plant.

The treatment process consists of chemical flocculation, sedimentation, rapid sand filtration and chlorination. Treated water stored in a 1,500 cu.m. reservoir is pumped into a 250 cu.m. elevated tank before it is distributed to the service area by gravity.

The distribution system of the waterworks covers the center of the municipality.

The number of connections increased from 1,531 in 1980 to 1,926 in 1983 and 2,550 in 1987. Although all house connections were metered, numerous meters were found to be defective or show measuring errors.

A detailed design has been prepared for the improvement of the existing sedimentation basin and sand filters in order to increase a treatment capacity to 240 cu.m./hour.

In 1987, Su Ngai Golok Waterworks had 2,550 connections. In this year, the total water production was 1,226,207 cu.m. while total water sale over 1,461,269 cu.m.

The annual water production and sales from 1980 to 1987 are shown in the following table:

Annual Water Production and Sales

Year	Water Production (cu.m/y)	Water Sales (cu.m/y)	No. of Conn.	Consump. per Conn. (cu.m/d)
1980	928,880	730,376	1,531	1.303
1981	1,076,460	807,851	1,595	1.427
1982	1,123,816	833,094	1,712	1.371
1983	1,357,506	951,165	1,926	1.391
1984	1,613,456	1,071,329	2,072	1.413
1985	1,527,501	1,081,895	2,253	1.353
1986	1,374,478	1,158,101	2,366	1.379
1987	1,461,269	1,266,207	2,550	1.399

POPULATION AND WATER DEMAND

Future served populations are calculated by area using the future service ratios and projected population therein as shown below:

Future Served Population

Year	Population in Service Area				Average Service Ratio (%)
	High Dens. Area	Med. Dens. Area	Low Dens. Area	Total	
1991	8,581 (12,258)	2,532 (12,660)	0 (7,268)	11,113 (32,186)	34.5
1996	10,318 (13,757)	4,575 (13,865)	1,461 (9,743)	16,354 (37,365)	43.8
2001	12,262 (15,327)	6,783 (15,073)	3,241 (12,965)	22,286 43,365)	51.4
2006	14,399 (16,940)	9,429 (16,257)	6,846 (17,115)	30,674 (50,312)	61.0
2011	16,709 (18,566)	12,170 (17,385)	11,202 (22,404)	40,081 (58,355)	68.7

Upper : Served population in the service area
Lower : Total population in the service area

For future water consumption, forecasts are made on five categories:

a) domestic water consumption

b) governmental/institutional consumption

c) tourism water consumption

d) commercial water consumption

e) industrial water consumption

The future water demand was calculated and summarized as the table below:

Daily Average Water Demand

(Unit : cu.m/d)

Category	1987	1991	1996	2001	2006	2011
Domestic	1,652	1,750	2,535	3,490	4,793	6,333
Gov't/Inst'l	447	612	659	712	775	847
Tourism	98	995	1078	1,114	1,130	1,136
Commercial	128	129	140	145	147	148
Industrial	27	28	38	50	67	86
Others	248	267	361	475	629	811
Sub-Total	3,489	3,781	4,811	5,986	7,541	9,361
Unaccounted-for Water Ratio (%)	13	13	13	13	13	13
Unaccounted-for Water	521	565	719	894	1,127	1,399
Daily Average	4,010	4,346	5,530	6,880	8,668	10,760
Peak Factor		1.30	1.30	1.30	1.30	1.30
Daily Maximum		5,650	7,189	8,944	11,268	13,988

DESIGN CRITERIA

The Design Criteria for the treatment system and pipeline was established based on the various design standards employed in Thailand and other countries, taking into consideration the conditions of the project site and raw water quality.

The design criteria is summarized as follows:

1. Water loss - a total of intake and treatment loss is 10 %; treatment loss is 8 %
2. Pipeline - velocity is a maximum of 3.0 m/s and a minimum of 0.3 m/s. Pipe material is steel for 400 mm diameter pipes or larger and A/C for 300 mm or smaller.
3. Treatment Plant - a) receiving well: treatment time is 1.5 min.; b) mixing tank: mechanical flush mixer; c) filter: rapid sand filtration; d) clear water reservoir: 8.0 hour retention time.
4. Distribution facilities - Minimum service pressure is planned at 1.0 kg/cm2 for hourly maximum flow.

BASIS OF COST ESTIMATE

The construction of the facilities to be built is calculated based on 1989 prices.

a) Pipelines - by linear meter for transmission and distribution pipes

b) Water treatment plant - PWA's data for the unit cost is used for the civil structures of the treatment plant. For the mechanical works, major items are counted individually. The cost of the electrical works are calculated by the percentage to the mechanical works.

The cost estimates are separated into foreign and local cost portions as shown here:

Item	Foreign Currency	Local Currency
Pipeline	(%)	(%)
A/C pipes	30	70
Steel pipes	80	20
Structural/Architectural	30	70
Mechanical Works	80	20
Electrical Works	80	20
Land Acquisition	0	100

Operation and maintenance costs, based on 1989 prices, consist of energy, chemical, manning, replacement and repair costs. Costs of the PWA's head office and the regional office allocated for this waterworks are also calculated and added in the financial study.

Part 2 - DEVELOPMENT PLAN

DEFINITION AND EVALUATION OF ALTERNATIVES

Evaluations made on several alternatives for the development of the Su Ngai Golok Waterworks revealed the following:

a. The PWA's plan to construct a new pumping station 7 km upstream of the existing intake, where raw water is less contaminated, is appropriate.

b. Construction of a new treatment plant with a maximum treated capacity of 9,400 cu.m./day is necessary to meet water demand by 2011.

Water source development plan calls for the construction of a pumping station at the proposed intake point. The work will be done in three stages, Phases 1, 2 and 3, as shown in the following table:

Water Source Development Plan

(Unit : cu.m/min)

Project	Year	Water Intake Capacity	Daily Maximum Water Demand
(1) Phase I Intake Pit Pump Sta.	1990	6,340	5,333 *)
(2) Phase II add Pump	1995	11,510	6,853
(3) Phase III add Pump	2003	16,700	9,814

*) : Maximum capacity of the existing treatment plant

New treatment plant with a maximum capacity of 9,400 cu m/day is proposed to be constructed at the PWA's land near the new raw water intake. The existing plant will also be in use in the future so that the total treatment capacity will be 15,160 cu m/day. An additional transmission pipeline is proposed to be laid from the new treatment plant to the service area. The pipe should be of steel with a diameter of 400 mm and a length of 6 km.

The proposed system is schematically shown in the Figure S-1.

IMPLEMENTATION PLAN

The implementation plan of the total project will follow projections on water demand. The construction of the treatment plant is proposed to be carried out in one phase. The construction of the transmission and distribution pipelines will be constructed in two years. Figure S-2 shows the water demand, the treatment capacity and the construction schedule of the facilities.

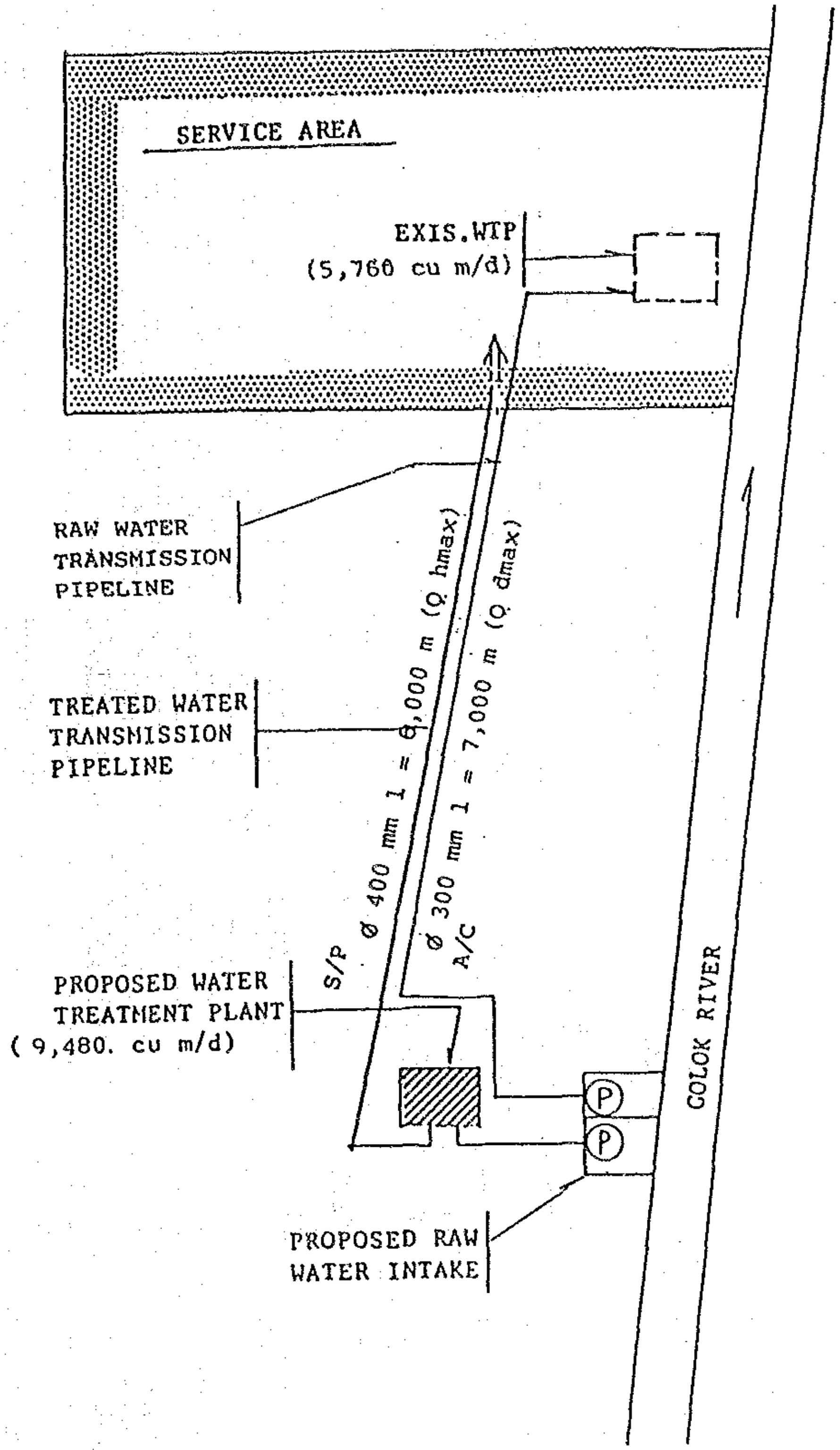


FIGURE S-1
SCHEMATIC PLAN FOR PROPOSED
TREATMENT PLANT SYSTEM
(ALTERNATIVE 3)

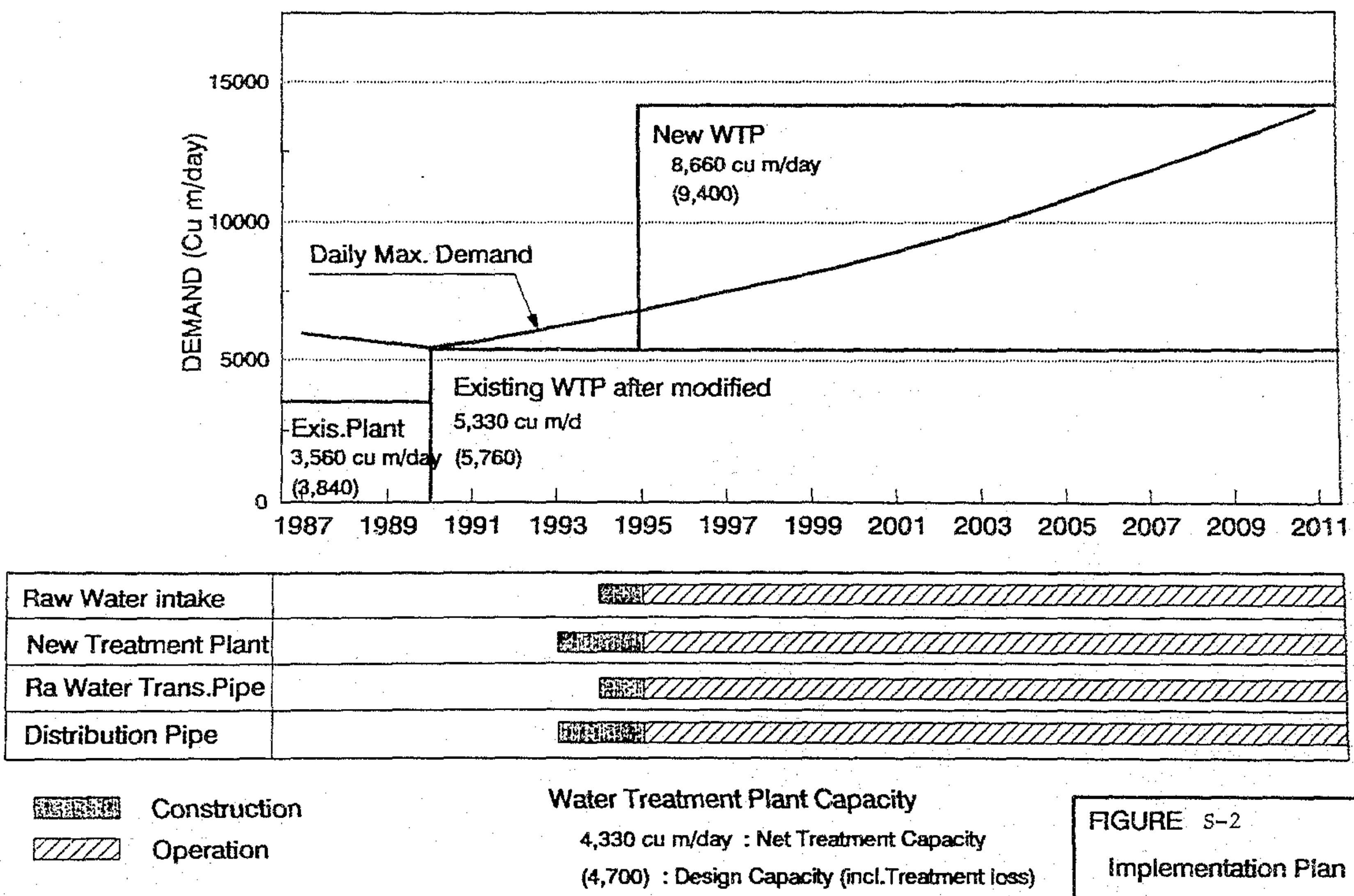


FIGURE S-2
Implementation Plan

ORGANIZATION OF WATERWORKS

The organization of the waterworks system will have to be expanded to include sections on administration, water production at new and existing plant, and the number of staff needed to run the system depending on water demand. Figure S-3 shows a proposed organization for the new system.

PROJECT COST ESTIMATES

(1) Construction Cost

Construction cost summary was based on the 1989 prices and was calculated for each facility component as shown in the Table below.

Summary of Construction Cost

(unit : Baht Million)

Item	Total Value	Foreign Currency Portion	Local Currency Portion
1.Raw Water Intake	4,320	2,192	2,128
2.Treatment Plant	35,944	26,172	9,772
3.Transmission Pipeline	17,400	5,220	12,180
4.Distribution Pipeline	26,787	8,036	18,751
Sub Total	84,451	41,620	42,831
5.Land Cost	0	0	0
Total	84,451	41,620	42,831

(2) Operation and Maintenance Cost

Operation and maintenance cost is calculated from the water demand in each year, and consists of energy, chemical, manning, repair, and replacement costs.

Total operation and maintenance cost is tabulated as follows:

Summary of Operation and Maintenance Cost
(unit : Baht 1000)

Year	Energy Cost	Chemical Cost	Manning Cost	Repair Cost	Total
1990	479		2,034		2,513
1991	1,302	164	2,136		3,602
1992	1,318	172	2,243		3,733
1993	1,335	180	2,467		3,982
1994	1,352	189	2,590		4,131
1995	1,646	199	3,833		5,678
1996	1,698	208	4,284	921	7,111
1997	1,748	218	4,498	921	7,385
1998	1,800	227	4,723	921	7,671
1999	1,855	238	5,109	921	8,123
2000	1,912	248	5,365	921	8,446
2001	2,080	259	5,633	921	8,893
2002	2,147	272	6,089	921	9,429
2003	2,216	284	6,941	1,365	10,806
2004	2,288	298	7,480	1,365	11,431
2005	2,418	312	8,055	1,365	12,151
2006	2,496	327	8,458	1,769	13,050
2007	2,575	341	9,103	1,769	13,788
2008	2,766	356	10,024	1,769	14,915
2009	2,850	372	11,015	1,769	16,007
2010	2,938	388	11,566	1,769	16,661
2011	3,029	405	12,414	1,769	17,618

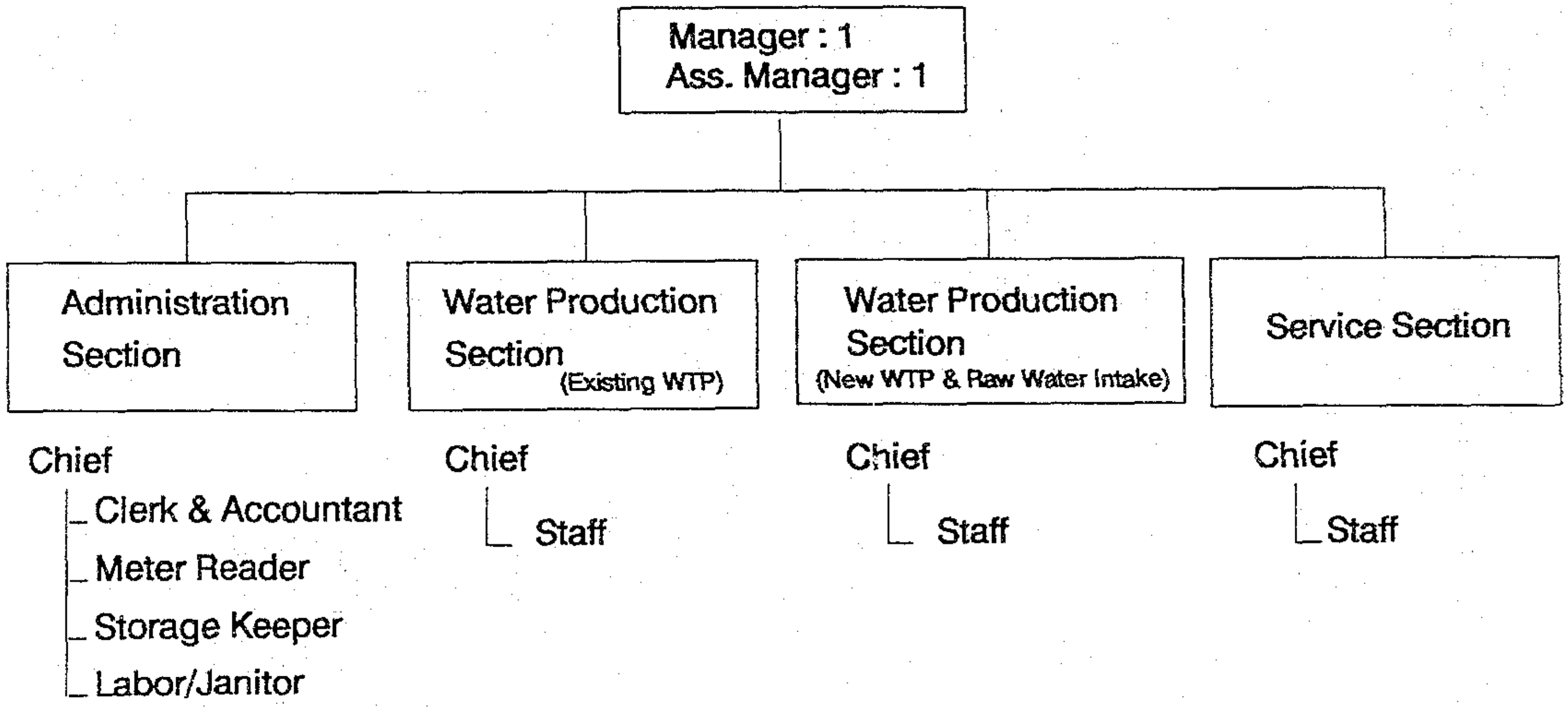


FIGURE S-3
Proposed Organization

Part 3 - FEASIBILITY STUDY

Preliminary Design

The preliminary design was prepared for the proposed facilities. T characteristics of the major facilities of the treatment plant are summariz as follows:

a. Receiving Well
   Type : Circular
   Dimension : Dia. 2.5 m x D 2.0 m
   No. : 1

b. Mixing Basin
   Type : Square
   Dimension : L 1.5 m x W 1.5 m x D 1.5 m
   No. : 2

c. Flocculator
   Type : Mechanical flocculation
   Dimension : W 1.7 m x L 12.0 m x D 2.5 m
   No. : 4

d. Sedimentation Basin
   Type : Rectangular with Inclining Plate
   Dimension : W 4.0 m x L 25.0 m x D 4.0 m
   No. : 4

e. Sand Filter
   Type : Rapid Sand Filter,
   Dimension : L 2.5 m x W 4.0 m
   No. : 8

f. Clear Water Reservoir
   Type : Rectangular
   Dimension : L 30.0 m x W 22.0 m x D 5.0 m
   No. : 1

g. Sludge Lagoon
   Type : Open Cut, Rectangular
   Dimension : L 10.0 m x W 8.0 m x D 2.0 m
   No. : 2

h. Sludge Drying Bed
   Type : Concrete Bed, Rectangular
   Dimension : L 5.0 m x W 15.0 m x D 1.0 m
   No. : 2

Financial Study

Project Cost Estimates

Total Project cost is estimated at 928,303 Baht, with a foreign exchange requirement of 538,063 Baht and local cost component of 390,240 Baht. The breakdown of cost estimates by phase is as follows:

	Foreign Portion	Local Portion	TOTAL
a. Construction Cost	41,616	42,833	84,449
Phase 1	41,327	42,552	83,879
Phase 2	289	281	570
b. Engineering Cost			
Design, 6% of (a)	3,663	3,768	7,431
Phase 1	3,663	3,768	7,431
Phase 2	0	0	0
Supervision, 2% of (a)	1,832	1,833	3,715
Phase 1	1,832	1,833	3,715
Phase 2	0	0	0
TOTAL	47,111	48,484	95,595
Phase 1	46,822	48,203	95,025
Phase 2	289	281	570

Financing Plan

The following financing schemes were considered:

Alternative 1: Total project cost financed from multilateral loan

Alternative 2: Foreign cost portion financed from bilateral loan; local cost from multilateral loan

Alternative 3: Foreign cost portion financed from bilateral loan; local cost equally financed from domestic loan and from PWA equity

Alternative 4: 70% of total project cost consisting all foreigncost. and 20,190 million Baht of local cost financed from bilateral loan; the remaining 28,294 million Baht of local cost equally financed from domestic loan and from PWA equity

Alternative 5: 70% of total project cost, consisting of all foreign cost and 20,190 million Baht financed from bilateral loan; 28,294 million Baht of local cost from domestic loan

Alternatives 3 and 4 are more desirable in view of lower funding burden for PWA. However, Alternative 4 is recommended over Alternative 3 due to lower fund requirements during construction stage.

Cash Flow Analysis

Inflows consist of government capital contribution for interest payment of domestic loan, foreign and local loan based on Alternative 4 financing scheme, water sales, connection fees, service charges, and other income including revenues from sales of materials, collected fines and about 2% of water sales. Water sales were projected using the current tariff structure until year 2020. Outflows consist of project expenditure, amortization based on Alternative 4 financing scheme, O&M, and connection expenses (50% of connection fees).

The result of this cash flow statement reveals that the annual net cash flow will not continuously raise profit surpluses throughout after 1994. The cumulative deficit will be 32,822 thousand Baht in 2010 and 85,833 thousand Balt in 2020, respectively.

Financial Internal Rate of Return (FIRR)

The project's internal rate of return on equity (IRROE), based on Alternative 4 financing scheme, was assumed to represent the FIRR. The IRROE, unlike the internal rate of return on investment (IRROI), takes into account the debt payments that have to be made each year. Also considered in the analysis was the salvage value of capital assets which was added to the benefit flows. Results indicate that NPV is -77,663 and B.C. Ratio is 0.31 so more soft loan or government subsidy are required to proceed the project.

ECONOMIC STUDY

The benefits were represented by the following: a) economic value of water, assumed to be 20% higher than the average rate per volume of water used in the financial analysis; b) health benefits, expressed as the reduction in cost of time lost and reduction in medical expenses (assuming 50% of waterborne diseases are caused by poor water supply system); c) increase in land values, assuming that land value increase for 7 years after construction of the project and 5% of the increase in land values is attributed to the availability of water supply system. Other expected benefits such as increased employment opportunities, intensified land use, increaed government tax revenues were not quantified.

The econoimc costs were calculated based on financial costs adjusted for the following: a) import duties and domestic tax assumed to be 10% and 5%, respectively; b) shadow prices for foreign and local currency of 1.00 and 0.95 respectively, and for unskilled labor of 0.5.

The project was found to be economically viable, with an economic internal rate of return (EIRR) of 11.63%, which is greater than the 9% opportunity cost of capital.

Part 1
GENERAL

Part 1 GENERAL

1. DESCRIPTION OF THE STUDY AREA

1.1 Natural Conditions

1.1.1 General

The Municipality of Su Ngai Golok is one of centers in Narathiwat Province, which is situated on the southeastern coast in the southern region of Thailand. It is a border town and enjoys commerce and tourism with the Malaysian people.

Su Ngai Golok is located at longitude 101°58' east and latitude 6°02' north, about 1,520 km south of Bangkok and 64 km southwest of Narathiwat.

The PWA waterworks supply water to the whole municipal area.

1.1.2 Topography

Su Ngai Golok, the southernmost Municipality of Thailand is bounded by the Golok River.

The Golok River, originates from Malaysia in Mt. Batu Tamong, flows into the Gulf of Thailand with an average annual discharge of 2,000 MCM and floods the low-laying area every monsoon season. In 20 km west of Su Ngai Golok, elevation exceeds 700 m and the land is generally too steep for agriculture purposes. Below these areas, the mountains form a series of subcatchments with easterly flowing streams into the Golok River.

Undulating middle terraces with isolated hills account for most of the area west of Su Ngai Golok. Elevations range between 40 - 80 m and most of this area is planted to rubber. The land below this, between 4 - 8 m, is flat to moderately sloping lower terraces.

1.1.3 Geology

Su Ngai Golok is situated on terrace deposits (Qt) consisting of gravel, sand, silt, clay and lateritec soils. The terrace deposit forms undulating middle terraces developed below the mountains. Alluvial deposits (Qa) are formed in the low-lying area along small streams that flow into the Golok River. The mountain area in the west of Su Ngai Golok is of granite and granodiorite (Kgr). Recrystalline limestone is found on the west side of the mountains.

Details of geological feature are given in Table 1-1-1.

Table 1-1-1 Geological Feature

Group	Feature	Location
Qa	Alluvial deposits; gravel, sand , silt and clay; recent and old beach sand	Scattered along small streams flowing into the Golok river
Qt	Terrace deposit; Gravel sand, silt, clay and lateritic soils	Undulating middle terrace between mountain and alluvial area along streams
Rgr	granite any granodiorite, midium to coarse-grained, porphyritic, with various xeuoliths	Mountains in the west of Sungai Golok
SDbt	Recrystalline limestone to marble, quartizit phyllite, phyllitic-schist and mica schist	The western side of mountains in the west of Sungai Golok

1.1.4 Meteorology

The annual rainfall in Su Ngai Golok averages 2,600 mm with highly seasonal distribution. As much as 50% of the total rainfall occurs during the period of the north-east monsoon from October to January. During this period, extensive flooding is common in the low-lying areas. Rainfall during the dry season, from February to June, is variable and unreliable.

Average annual pan evaporation level is about 1,700 mm with little monthly variation. Relative humidity is high, ranging from 86% in November to 78% in April. The mean monthly temperature varies from 28.5°C in April to 26.1°C in January with a range of only 2.4°C. The extreme range is from 39°C to 17.1°C.

Details of meteorology are given in Table 1-1-2.

Table 1-1-2 Meteorological Data at Sungai Golok

Items	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temperature (C.degree)													
Mean	26.1	26.8	27.6	28.5	28.4	28.0	27.6	27.5	27.3	27.0	26.2	25.8	27.2
Mean Max.	29.9	30.9	32.0	33.1	33.0	32.6	32.3	32.2	32.0	31.0	29.5	29.0	31.5
Mean Min.	22.2	22.4	22.8	23.5	23.9	23.5	23.2	23.2	23.1	23.2	23.1	22.9	23.1
Ext. Max.	33.6	35.1	36.6	36.4	39.0	36.7	36.2	36.5	36.4	36.0	33.5	32.6	39.0
Ext. Min.	17.1	17.5	19.0	19.8	20.5	21.0	20.7	20.6	20.2	20.3	18.7	19.8	17.1
Relative Humidity (%)													
Mean	80.8	79.0	78.4	77.7	79.2	79.0	79.8	79.9	80.5	83.2	86.4	85.6	80.8
Mean Max.	94.2	93.8	94.1	93.6	93.9	94.1	94.7	94.6	94.7	95.8	96.9	75.1	94.7
Mean Min.	68.7	66.8	64.8	63.5	64.5	63.9	64.9	64.6	65.0	69.9	75.5	75.5	67.3
Ext. Min.	49.0	47.0	40.0	50.0	41.0	37.0	39.0	43.0	42.0	46.0	53.0	56.0	37.0
Evaporation (mm.)													
Mean - Pan	117.7	113.4	140.4	145.3	142.4	123.2	126.5	131.0	121.8	123.0	101.1	xx	-
Rainfall (mm.)													
Mean	145.0	46.4	86.2	65.9	135.5	125.9	151.1	162.7	196.6	295.6	632.3	534.6	2577.8
Mean Rainy Days	14.1	8.2	6.6	7.2	13.1	12.6	13.8	14.9	16.6	20.3	23.0	23.1	173.5
Greatest in 24 hr.	424.6	42.4	154.2	109.9	94.7	79.3	98.5	86.3	124.3	145.9	366.1	291.5	424.6
Day / Year	6/67	15/64	25/73	23/79	30/68	27/74	12/85	03/83	19/68	20/65	28/59	4/66	6/67

Source : Meteorological Department
Remark : Evaporation 1982-1985
: xx = The Instrument Failure

1.2 Socioeconomic Conditions

1.2.1 Economic Conditions

In 1986, the total employment in the area was 9,877 which accounts for 32.6% of the population as in Table 1-2-1.

Table 1-2-1 Population and Labor Force

(Unit : persons (%))

Total population	30,350 (100.0)
Population over 10 years old	22,340 (73.6)
Labor force	11,858 (39.1)
Employed	9,877 (32.6)
Unemployed	1,981 (6.5)
Non labor force	10,482 (34.5)
Housewives	3,832 (12.6)
Students	3,583 (11.8)
Handicapped	591 (2.0)
Volunteers	2,351 (7.7)
Others	125 (0.4)
Population of 10 years old or less	8,010 (26.4)

Source : DTCP

In the primary sector, rubber plantations provide major job opportunities.

In the secondary sector, there are 20 manufacturing establishments and 30 maintenance/repair shops and other service shops as shown in Table 1-2-2.

In the tertiary sector, there are 840 commercial, business and service establishments. In addition to shops for daily necessities, establishments for service sectors account for a considerably large share as in Table 1-2-3.

Regarding economic activities in the area, the following features should be noted.

(1) The unemployment ratio is high at 16.7%. In addition, there seems to be a considerable number of "under employed" such as motorcycle-taxi drivers. Therefore, means to further boost its economy and employment should be pursued.

Table 1-2-2 Number of Factories by Industry Type

No.	Industry of Type	No. of Factories
1.	Food and Beverage Product	6
2.	Metallic Product	6
3.	Rubber Product	1
4.	Cementing Equipment Product	2
5.	Lumber	1
6.	Furniture, Window & Door Frame Product	2
7.	Printing (Including Sarong Cloth)	3
8.	Machinery Repair	21
9.	Electricity Repair	4
10.	Others	4
	Total	50

Source : DTCP

Table 1-2-3 Number of Some Major Business Offices in Municipal Area

Type of Business	1982	1983	1984	1985	1986
Grocery Shop	98	109	117	126	148
Food Shop	82	85	89	93	105
Medical Shop	2	4	7	10	12
Cloth Shop	25	35	40	60	100
Dress Making Shop	13	20	26	32	41
Beauty Shop	45	47	52	64	78
Bookseller Shop	1	3	5	6	8
Electric Appliance Supply Shop	8	11	15	19	23
Hotel	17	23	32	48	56
Vendor	64	69	75	78	80
Service Shop	31	45	58	65	77
Medical Clinic	2	4	6	8	10
Cinema	2	2	2	2	2
Others	20	25	25	30	100
Total	410	482	549	641	840

Source : Five Year Plan of Su Ngai Golok Municipality

(2) The most prominent economic activity in the area is tourism such as entertainment, restaurants and shops, as well as regional tours. The number of tourists depends on external factors such as the economy of Malaysia, from which most tourists visit the area. The development of tourist service facilities is also important.

At present, there are 57 hotels with the total of 2,063 rooms mostl located at the central commercial district. In a couple of years, new hotel with 220 rooms will be opened at the east side of th central commercial district.

Currently a tourism development plan for Narathiwat Province is bein prepared by TAT.

(3) For development of secondary industry, the following possibilitie should be studied:

- Development of industries supporting local communities such as food stuffs and construction.
- Development of local resource oriented industries such as wood-working or rubber processing.
- Development of tourism related industries such as handicrafts

1.2.2 Transportation

In the Su Ngai Golok Municipality, two inter-city roads meet. One is Route 4056 connecting the Municipality with Narathiwat and the other is Route 4057 connecting Tak Bai and Waeng though the Municipality as shown in Figure 1-3-1.

Local roads are developed only in the central town. The roads to the river are mostly at dead ends there and roads connecting the dead ends along the river are lacking. Outside the central area, the local road network is not developed.

On the north of Route 4056 is the railway line connecting Thailand to Malaysia. The station on the north of the municipal center serves passengers and cargoes, attached with yards for lumber, one of the major products of the region.

The bridge over the Golok River serves frequent traffic between the two countries. In addition, boat services across the river are important means of daily transport of local people and commodities.

1.2.3 Education

Education system in Thailand is divided into three levels: primary, secondary and tertiary.

In recent years, pre-primary education, including kindergarten, has become available to children of ages three to five. Children enter primary school when they are anywhere between six to eight years old, depending largely on the locality. Secondary education is divided into lower and upper divisions each consisting of three years such that, typically, those 12-14 years of age attend lower secondary while those 15-17 attend upper secondary.

The government plays a major role in all aspects of Thailand's education system. Government expenditure on education as a percentage of total government expenditure varies from 19% to 21% in recent eight years. The percentage of government expenditure on education in Thailand is among highest compared to other developing countries.

In Su Ngai Golok, there are 17 schools. A detailed break down of schools, including the number of students is shown in Table 1-2-4.

Table 1-2-4 School in Amphoe Su Ngai Golok

Grade of School	No. of Schools	No. of Students	No. of Teachers
Kindergarten	9	1,097	130
Primary School	5	1,748	95
Secondary School	3	1,709	105
College/University	-	-	-
Total	17	4,554	330

1.2.4 Sanitation (Water-borne Diseases)

In developing countries, three people out of the five do not have access to clean drinking water. According to WHO, about 80% of sicknesses are caused by unhygienic water and defective sewage treatment. Thus, the quality of drinking water is closely related to human health.

To decrease the incidence of water-borne diseases is one of the more significant purposes of a water supply project. The status of water-borne diseases in relation to the number of patients is shown in Table 1-2-5.

Table 1-2-5 Water-Borne Diseases in Su Ngai Golok

Year	No. of Patients					
Year	Diarrhea	Dysentery	Food Poisoning	Typhoid	Cholera	Total
1985	534	70	32	38	1	675
1986	381	128	34	110	1	654
1987	294	130	98	205	2	729

1.3 Land Use

1.3.1 Existing Land Use Pattern

Existing land use is shown in Figure 1-3-1. The main features of the pattern are as follow:

(1) Most commercial facilities including hotels and restaurants, and high density residential areas are concentrated between Route 4056 (Asia 18 Road) and the Prachavivat Road. On the northern side of the station are government facilities such as the Amphoe and Municipality offices, the public hospital and the public park.

(2) In the urban area, land use is mixed such as residence, commerce, business, small scale factories and workshops. Even in the central districts, vacant spaces are common behind buildings along main roads.

(3) There are private housing projects on the peripheries of the urbanized areas.

(4) Southwestern areas are mostly forests including many rubber plantations where the local road network is not well developed.

1.3.2 Land Value

In the Municipality, land prices are higher in the central commercial areas especially around the intersection of Route 4057 (Charernkhet Road) and the Prachavivat Road. Typical official land prices of these areas are 2,000 ฿/sq.m (3,200,000 ฿/rai) up to 6,250 ฿/sq.m (10,000,000 ฿/rai).

The farther from the center and main roads is an area, the lower is the land price. In these areas, typical official land prices do not exceed 100 ฿/sq.m (160,000//rai).

Actual market prices of land are thought to be higher than the official prices.

1.3.3 Future Land Use Pattern and Development Prospects

The future land use plan by DTCP expects urban and housing development in the eastern half of the area as shown in Figure 1-3-2. The commercial and high density residential areas will cover the existing urban center and the expansion along Route 4057 (Charernkhet Road) to the south surrounded by medium density residential areas. Low density residential areas will be expanded covering almost the rest of the eastern half of the area including presently rural areas. The area on the north of the railways will be mostly developed as medium and low density residential areas.

In the western half, which will remain mostly as rural and agricultural areas, an industrial/warehouse area is designated.

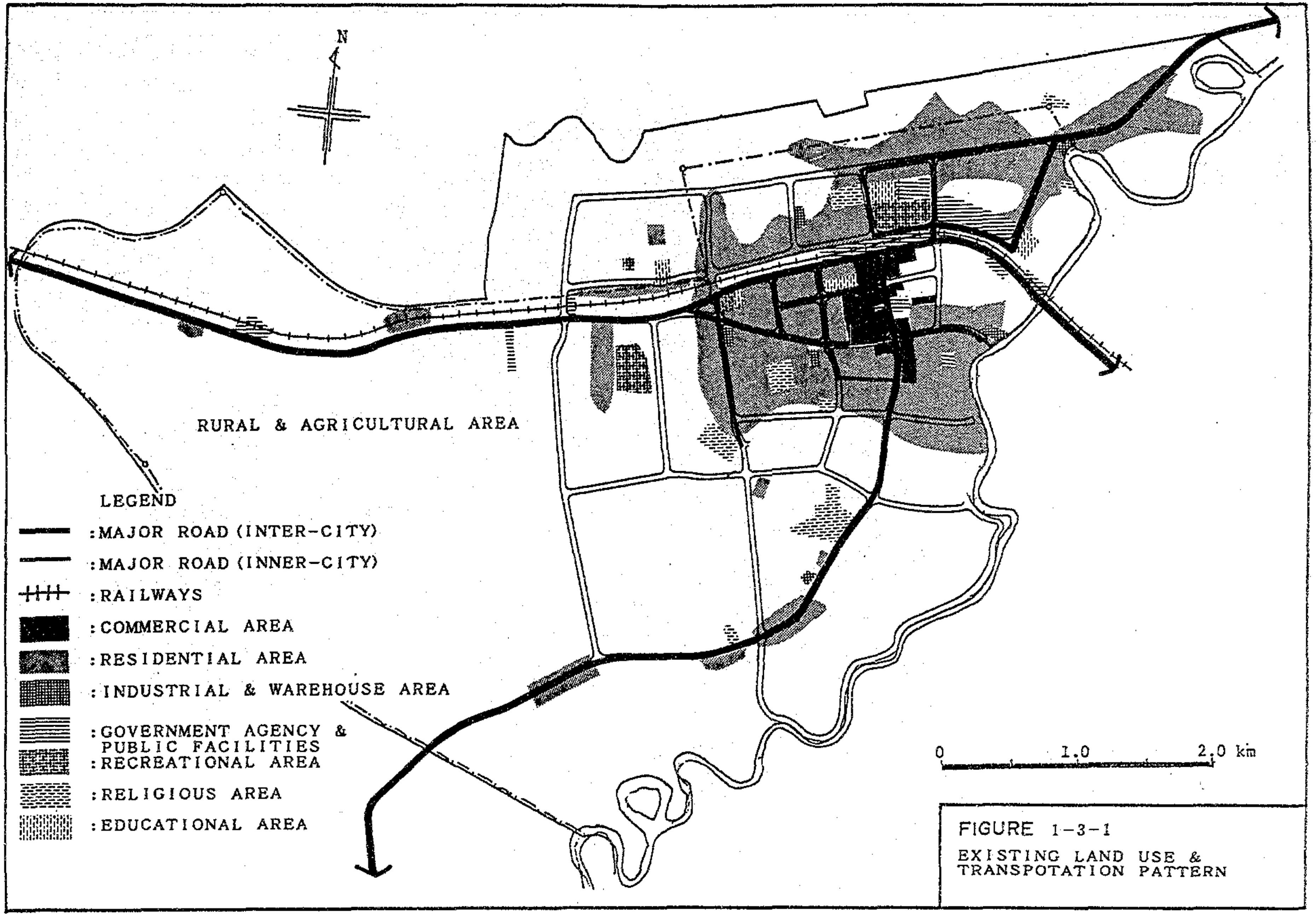


FIGURE 1-3-1

EXISTING LAND USE & TRANSPOTATION PATTERN

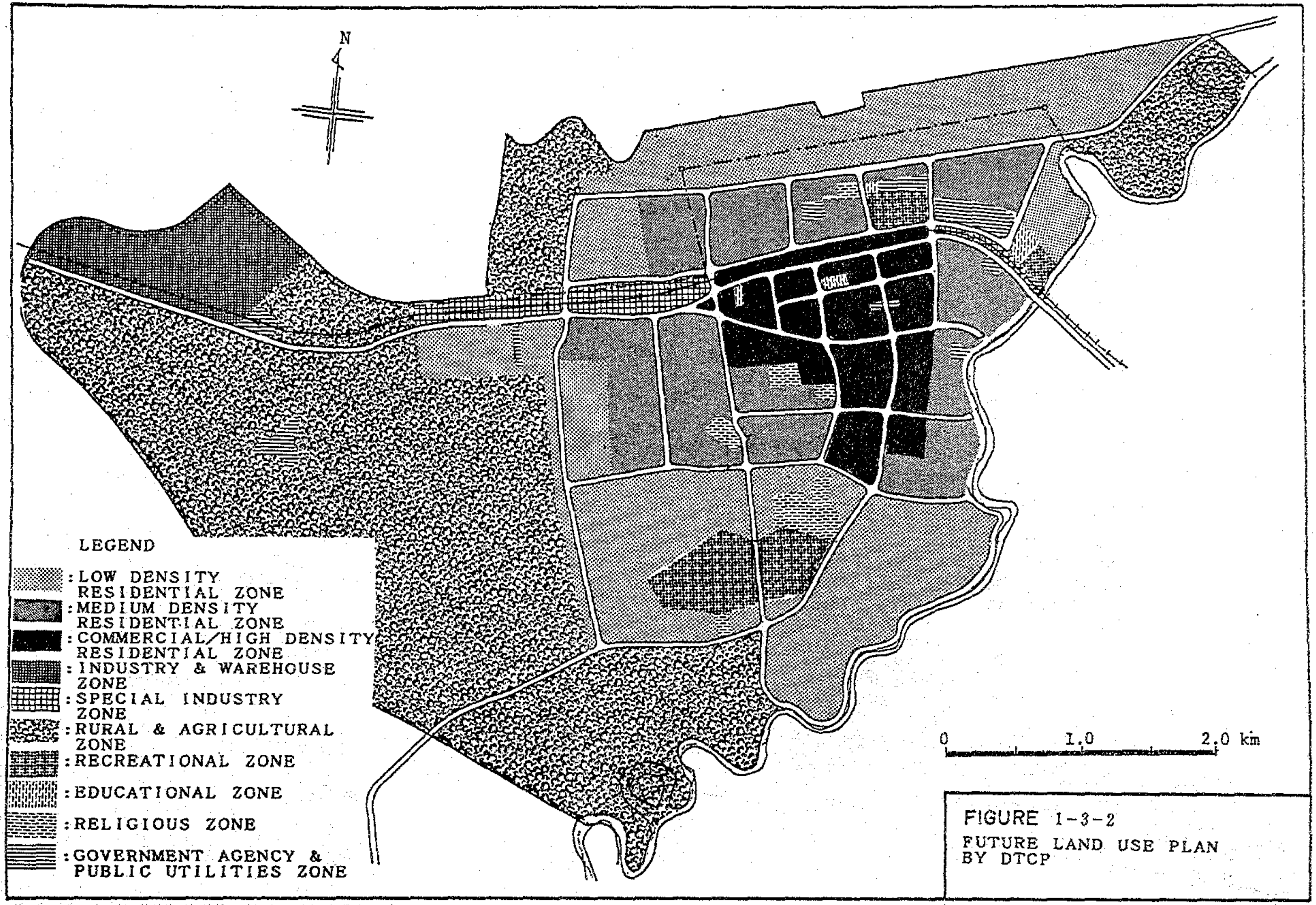


FIGURE 1-3-2
FUTURE LAND USE PLAN BY DTCP

The local road network will also be developed to serve mainly the newly urbanized areas including the one along the river.

There is no long-term development plan for the Municipality besides the town plan. However, in order to realize the high growth expected in the town plan, rapid economic growth is to be achieved taking full advantage of the potential of the area. In addition to the local natural resources, the location at the border of the two countries is the most important resource of Su Ngai Golok, by which tourism, commercial and business activities are expected to be further promoted.

2. WATER SOURCE

2.1 Existing Water Use Pattern

2.1.1 General

Main water sources for water supply are the Golok River and a number of shallow wells and a few deep wells. A pump station is located 200 m east of the Su Ngai Golok Waterworks which is constructed for the purpose of supplying water to the Su Ngai Golok municipal area. Most of the inhabitants rely on a number of shallow wells or the combination of both the PWA water supply system and shallow wells.

Major constraints in water supply are the allowable intake quantity from the Golok River during the dry season and contamination in shallow wells.

2.1.2 Surface Water

(1) Golok River

The Golok River shown in Figure 2-1-1 originates in the highland region southwest of Su Ngai Golok on an elevation of about 800 m and flows northeast. The river falls rapidly over a distance of 10 km to an elevation of about 20 m. The river meanders northwards, and is jointed by number of small tributaries, of which the larger ones are the Khlong Bala, Khlong Lo Chud, Khlong Niru, Khlong Waeng and Khlong Ma Yae on the left bank, and S. Todok on the right.

The catchment area at Su Ngai Golok is 774 sq.km. During floods, the flows in the river increase dramatically and overflows into the flood plains. Floods typically continue for one to two weeks and are limited to December to mid-January. During March to May, on the other hand, the flows fall to the level which limit water usage for irrigation and water supply.

According to the flow records gauged by RID at Su Ngai Golok, the annual average flow is 2,000 MCM, the highest flow reaches 576 MCM in December but the lowest one falls to 1.85 MCM in April.

The quality of raw water tested during the field survey is presented in Table 2-1-1.

(2) Rainwater

Rainwater collection is one of the most traditional water supply in the rural area throughout Thailand.

This device are rarely seen in the Municipality although it is a source of good quality water.

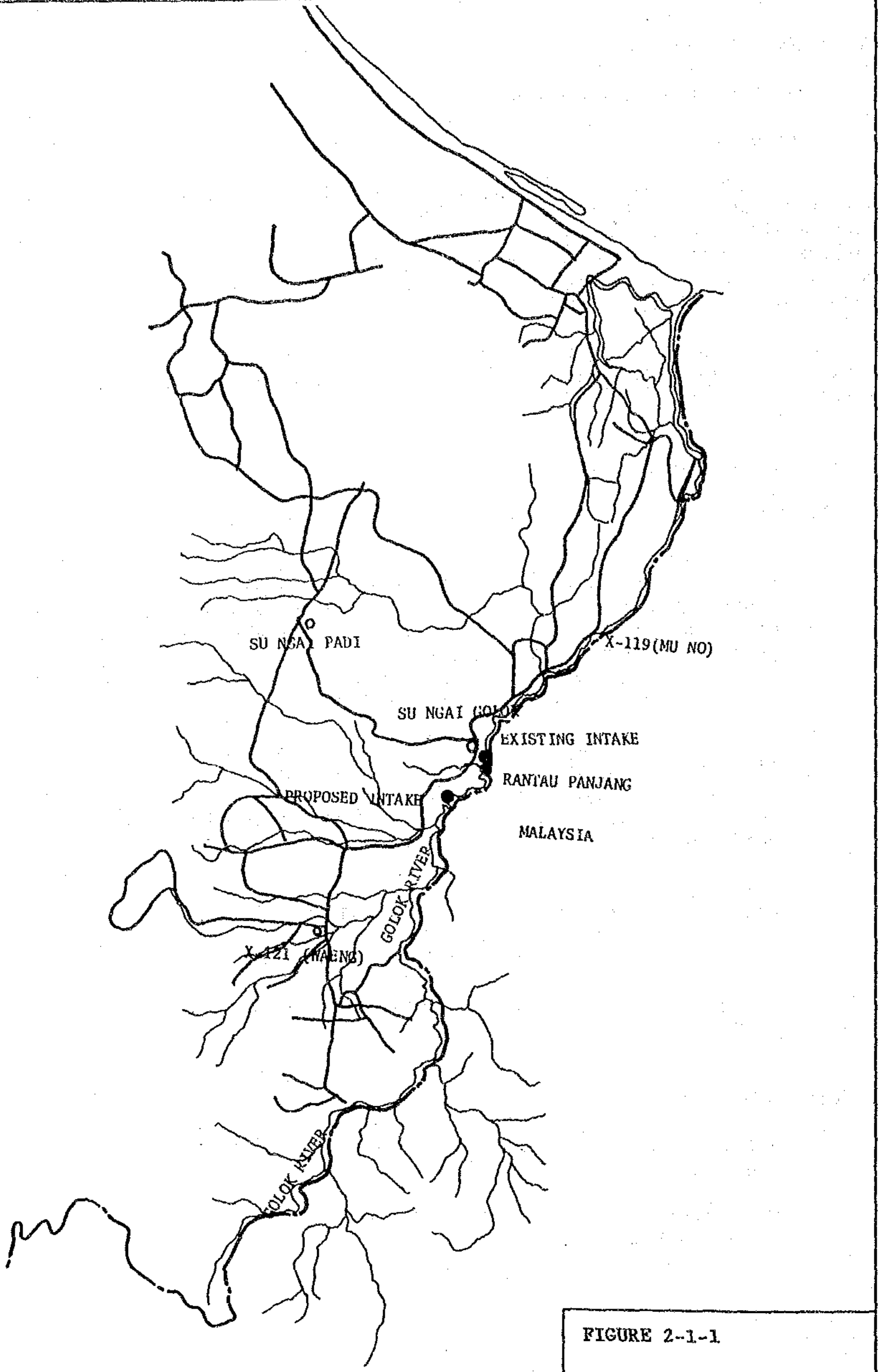


FIGURE 2-1-1

LOCATION OF WATER SOURCE

Table 2-1-1 Raw Water Quality

Parameter	Existing Intake Point	New Intake Point
1. Phisical		
Color	20	20
Turbidity	28	20
pH	6.52	7.54
Conductivity at 25°C	24	76
2. Chemical		
TDS	32	49
Total Hardness	12	22
Temporary Hardness	10	22
Permanent Hardness	2	nil
Alkalinity (PP)	nil	nil
Alkalinity (M)	10	24
Ca	2.4	7.2
Mg	1.4	1.0
Chloride	5	5
Mn	nil	nil
Cu	nil	nil
Zn	nil	0.06
SO4	2.0	2.0
Nitrite	0.08	0.08
Nitrate	nil	nil
F	nil	nil
As	0.0013	0.0011
Cd	0.002	0.0011
Cr	0.0029	0.0029
Pb	0.0020	0.0076

Note : Sampled on Augusr 23, 1988

2.1.3 Ground Water

(1) Shallow Well

The shallow well is commonly used as the alternative water source for domestic purpose or supplementarily used for a PWA water supply system. It is mostly hand-dug with a depth of 5 to 10 m and a diameter of 1.0 to 2.0 m and constructed with concrete or brick lining. In most of wells water is drawn by a bucket and rope, and the daily usage is estimated to be less than 1 cu.m/d.

The well used in such institutions as schools, hospitals, temples, mosques and governmental offices are often equipped with an electric motor pump and an elevated storage tank. They are usually constructed with a concrete structure.

Most of the hotels and restaurants are also provided with bigger concrete wells with depths over 20 m.

The quality of well water is fairly unhygienic because of the contamination caused by floods or wastewater intrusion. Turbidity is higher as being near to the Golok River because river water intrudes without proper filtration. NH_4-N or coliform contents are often observed around the center of the town. The quality is being improved as being away from the river to the hilly area.

The water quality tested during the field survey is given in Table 2-1-2.

(2) Deep Well

A few of the institutions have a tube well in addition to a hand-dug well. Such wells have been constructed by government agencies as DMR. However, any tube wells are not constructed by DMR in the study area.

The small tube wells are typically constructed with a 100 or 125 mm diameter PVC pipe and equipped with a hand pump. Those installed at Peter Village have 100 mm diameters, 40 m depths and 8 cu.m/h yields and equipped with electric-submersible pumps, a filter and elevated tank.

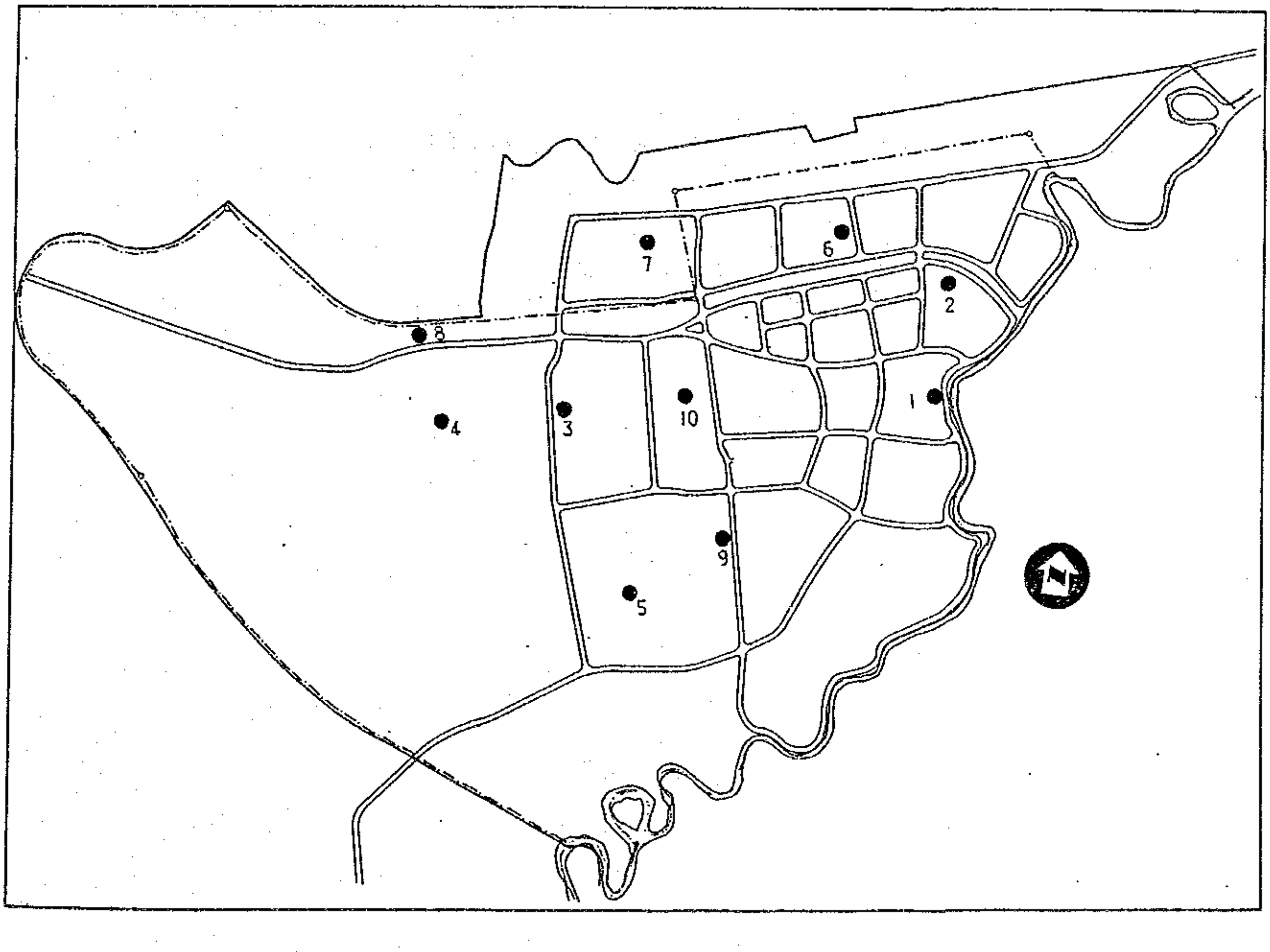
Because of the high iron content of ground water, treatment by aeration and settling or filtering is necessary especially for hospitals. The high iron content discourages the inhabitants to use well water.

Table 2-1-2 Water Quality of Shallow Well
(Tested in August 1988)

Sampling Point	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10
Type	Resi-dent	Resi-dent	Shop	Resi-dent	Rest.	Hotel	Tem-ple	Fire St'n	Fac-tory	Rest.
Temp.	29.5	29.5	27.5	27.5	28.3	28.3	28.3	28.3	28.3	28.7
pH	6.3	5.8	4.8	5.1	4.7	5.5	6	5.7	5.2	7
Turb.	7.5	39	1.5	4	3.2	2.5	1	3	1	48
Cond. (x5x100)	24.5	7.8	16.8	20	18.5	18.5	12.5	14.5	20.5	6x500
NH_4-N	0.4-0.8	0.4-0.8	Tr.	1.6-4	0.4-0.8	Tr.	0.4-0.8	ND	ND	8.0
NO_2-N	0.006	0.015-0.03	Tr.	ND	ND	ND	Tr.	ND	0-0.06	0.15-0.03
Coli.	D	D	D	D	D	ND	ND	ND	D	D

Tr. : Trace, ND : Not Detected, D : Detected

Figure 2-1-2 Location of Water Sampled



2.2 Availability of Existing Water Source

2.2.1 Data Available for the Study

(1) General

The data required for the hydrological studies are meteorological data as rainfall and evaporation, and hydrological data as water level and discharge in the monthly base. MD and RID is responsible for collecting and processing the data on meteorology and hydrology, respectively.

Rainfall data recorded at the amphoe office is sent to the MD headquarter, Bangkok for data processing.

All water level records are sent directly to the RID headquarter, Bangkok for data processing.

However, the Golok River has a catchment area in both Thailand and Malaysia. Those data required for the study is quoted from the Golok River Basin Development Study prepared by the Australian Development Assistance Bureau in association with the Ministry of Agriculture and Cooperative.

(2) Monthly Rainfall

Monthly rainfall data are available at four gauging stations in the Thai side catchment area of the Golok River, but are not available in the Malaysian side.

The rainfall stations are listed below and monthly rainfall data are given in Tables A1-1-1 to A1-1-3 in Appendix A-1-1.

Table 2-2-1 List of Rainfall Station

Station	Location	Period of Record	Remarks
Waeng	05 55'33"N 101 53'12"E	1922 to 1928 1930 to 1939 1977 to Present	Gauge was found leaking. New gauge was installed in Oct. 1983.
Su Ngai Golok	06 01'39"N 101 58'08"E	1968 to Present	Poor exposure
Su Ngai Padi	06 05'00"N 101 53'00"E	1922 to 1928 1930 to 193 1971 to Present	Poor exposure

(3) Climatological Data

The data describing climatology in Su Ngai Golok is only available at Narathiwat. This station observes such climatological data as temperature, atmospheric pressure, humidity, evaporation, sunshine hours and wind. The data is given in Table A1-1-4 in Appendix A-1-1.

(4) Hydrological Data

The hydrological stations, X-119, X-121 and X-151 in-stalled by RID have water level and discharge data available in the Thai side, and the station at Rantau Panjang installed by the Malaysian government have also water level and discharge data available in the Malaysian side.

The hydrological gauging stations are listed in Table 2-2-2 and those data are given Tables A2-1-1 and A2-1-2 in Appendix A-2-1.

Table 2-2-2 List of Rainfall Station

Station	Location	Period of Record	Remarks
Thailand			
X-119 (Su Ngai Golok)	06°04'09"N 102°02'09"E	Dec. 1980 to Present	Bypassing during flood flows
X-121 (Waeng)	05°55'29"N 101°53'11"E	Nov. 1980 to Present	
X-151 (Waeng)	5°58'36"N 101°56'20"E	1984 to Present	
Malaysia*			
Rantau Panjang (Su Ngai Golok)	06°01'30"N 101°58'40"E	1962 to 1974 1977 to Present	Coricorder recorder 1924-77 Data not processed Staff gauge readings 1983-84 Bypassing during flood flows

* Source : Golok River Basin Development Study

(5) Hydrogeological Data

Data available are only the hydrogeological map prepared by DMR, the Golok River Basin Development Study Report and the Bang Nara Irrigation and Drainage Project Feasibility Study Report.

2.2.2 Availability of Existing Water Source

(1) Discharge Data

(a) Rantau Panjang

The rating curve was plotted on the log-log graph paper using a stage of 3.5 m to linearize in the 1980-1983 curve. It can be seen from the rating curve given in Figure A2-2-1 in Appendix A-2-2 that there has been a substantial shift in the low flow section of the curve due to assertion in the gauging reach.

At high flows (above a stage of about 9.4 m) overspill commences upstream of the gauging station, resulted that flood flows are underestimated. Therefore, although this rating curve is fairly well defined throughout the whole range of flows, there are problems due to the shifting at low flows and bypassing at high flows.

(b) X-119 (Mu No)

Prior to January 1984 when a gauging winch was installed, gauging, which had been done by a boat and tag line due to poor station location and fixing the section, is poor at low flows when there is flow reversal about 20 m from the left bank. At high flows by pass considerably. A rating curve is given in Figure A2-2-2 in Appendix A-2-2.

Overall accuracy is poor with flood flows totally unrepresentative of catchment discharge, and mean errors of about 15% are expected.

(c) X-121 (Waeng)

Discharge are plotted on log-log scales given in Figure A2-2-3 in Appendix A-2-2. The low flow control is not very sensitive, and the range of measured flows was only from 0.25 to 52 cu.m/h.

Most of the recent gaugings appear to be low compared with the previous values. The fitted curve was used to calculate the flood discharge, but not for processing the daily data, the likely errors of which are believed to be about 10 to 15%.

(2) Availability of Existing Water Source

(a) Low Flow Analysis

The Golok River Basin Development Study reported that low flow analysis from the data processed during the study for 1981-1983 resulted in 2.5 cu.m/s for once in 10 years, 30 day low flow.

The results are shown in Tables 2-2-3 and 2-2-4 and actual flows are referred from Figure 2-2-1.

(b) Availability

Water demand in the target year of 2011 is estimated at 0.137 cu.m/s including the intake loss. Therefore, the existing and newly proposed water source have sufficient flows even in the return period of 1/10 as shown in Figure 2-2-2 and Table 2-2-5.

Table 2-2-3 Minimum Flow Analysis for the Golok River at Rantau Panjang

(Unit : cu.m/s)

Year	Minimum Discharge for Duration (Days) 1	3	7	14	30
1963	3.73	3.84	3.95	4.18	4.75
1964	10.93	10.94	11.1	13.17	15.28
1965	5.15	5.69	6.65	7.3	10.28
1966	5.38	5.91	6.78	8.82	13.2
1967	10.56	11.09	12.04	14.31	18.71
1968	1.75	1.8	1.93	1.9	2.23
1969	1.53	1.56	1.59	1.5	1.8
1970	8.86	8.93	9.34	11.24	11.96
1971	4.94	5.09	5.43	6.01	6.44
1972	5.12	5.21	5.61	5.77	7.79
1973	7.72	7.74	7.88	8.6	12.3
1974	11.67	12.25	13.32	15.9	17.3
1975	-	-	-	-	-
1976	-	-	-	-	-
1977	4.47	4.47	4.73	4.88	5.05
1978	7.38	7.62	8.11	9.43	9.44
1979	6.24	6.33	6.41	6.51	7.12
1980	6.62	6.69	6.81	7.13	8.42
1981	3.42	3.52	3.66	4.3	5.05
1982	2.08	2.14	2.21	2.24	3.06
1983	0.93	0.96	1.01	1.09	1.33

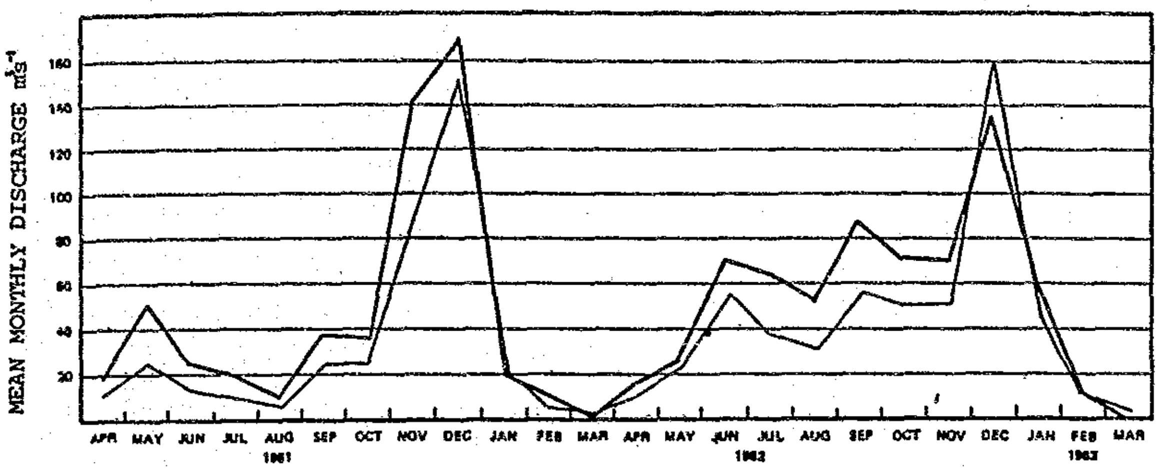
Table 2-2-4 Frequency Analysis of Annual Minimum Series Flows for the Golok River at Rantau Panjang

nit : cu.m/s)

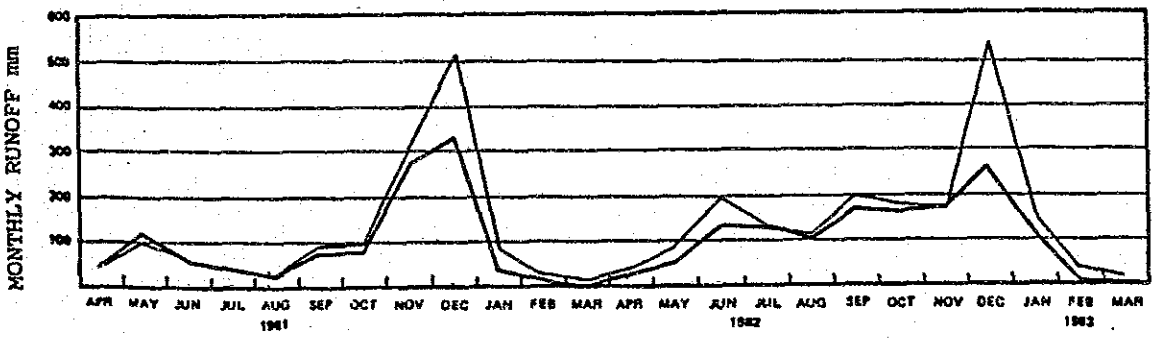
Duration Days	Minimum Flow for Return Period (Years) 2	5	10	20	30
1	4.7	2.6	1.9	1.5	1.1
3	4.8	2.7	2.0	1.5	1.1
7	5.1	2.8	2.1	1.6	1.2
14	5.6	2.9	2.1	1.6	1.2
30	6.7	3.5	2.5	1.9	1.4

Source : Golok River Basin Development Study

A. MEAN MONTHLY DISCHARGE



B. MONTHLY RUNOFF



LEGENO

——— S. GOLOK AT RANTAU PANUANG

——— S. GOLOK AT MUNO

SOURCE : GOLOK RIVER BASIN DEVELOPMENT STUDY

FIGURE 2-2-1
MONTHLY FLOW AT PANTAU
PANJANG AND MU NO

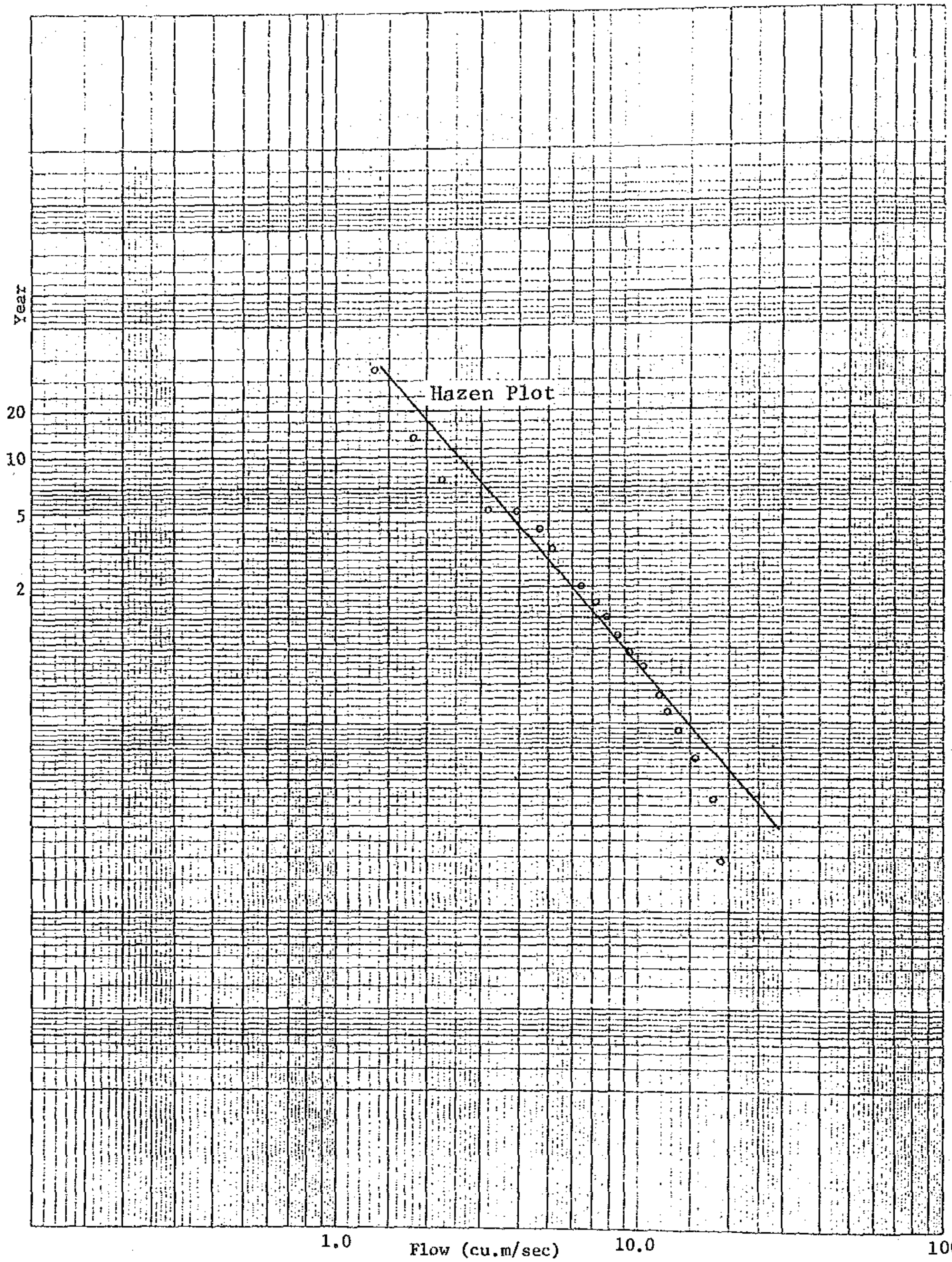


FIGURE 2-2-2
LOGARITHMIC NORMAL
DISTRIBUTION

Table 2-2-5 Monthly Flow of the Golok River at Rantau Panjang

************* NON-EXCEEDANCE PROBABILITY BY IWAI METHOD ***********************

ORDER	YEAR	X	LOG-X	Y=X+B	LOG-Y	(LOG-Y)**2	TOMAS(%)	HAZEN(%)	X**2
1	1982	1.33	0.12385	4.166	0.61969	0.38401	95.00	97.37	1.769
2	1969	1.80	0.25527	4.636	0.66612	0.44371	90.00	92.11	3.240
3	1968	2.23	0.34830	5.066	0.70464	0.49652	85.00	86.84	4.973
4	1981	3.06	0.48572	5.896	0.77054	0.59373	80.00	81.58	9.364
5	1963	4.75	0.67669	7.586	0.88000	0.77439	75.00	76.32	22.562
6	1976	5.05	0.70329	7.886	0.89684	0.80432	70.00	71.05	25.503
7	1980	5.05	0.70329	7.886	0.89684	0.80432	70.00	71.05	25.503
8	1971	6.44	0.80889	9.276	0.96735	0.93576	60.00	60.53	41.474
9	1978	7.12	0.85248	9.956	0.99807	0.99615	55.00	55.26	50.694
10	1972	7.79	0.89154	10.626	1.02636	1.05341	50.00	50.00	60.684
11	1979	8.42	0.92531	11.256	1.05137	1.10538	45.00	44.74	70.896
12	1977	9.44	0.97497	12.276	1.08905	1.18602	40.00	39.47	89.114
13	1965	10.28	1.01199	13.116	1.11779	1.24946	35.00	34.21	105.678
14	1970	11.96	1.07773	14.796	1.17014	1.36922	30.00	28.95	143.042
15	1973	12.30	1.08991	15.136	1.18000	1.39241	25.00	23.68	151.290
16	1966	13.20	1.12057	16.036	1.20509	1.45224	20.00	18.42	174.240
17	1964	15.28	1.18412	18.116	1.25806	1.58270	15.00	13.16	233.478
18	1974	17.30	1.23805	20.136	1.30397	1.70033	10.00	7.89	299.290
19	1967	18.71	1.27207	21.546	1.33336	1.77785	5.00	2.63	350.064
TOTAL		161.51	15.74406		19.13526	20.10194			1862.858
(1/N)		8.50	0.82863		1.00712	1.05800			98.045

GOLOK RIVER (RANTAU PANJANG)

******* COMPUTATION OF B **

ORDER	XI	XS	XI*XS	XI+XS	XI*XS-X0**2	2X0-(XI+XS)	BI
1	1.330	18.710	24.884	20.040	-20.538	-6.561	3.130
2	1.800	17.300	31.140	19.100	-14.282	-5.621	2.541
TOTAL							5.671
						B=	2.836

******* MONTHLY FLOW(MIN) LIST OF RETURN PERIOD****************

RETURN PERIOD YEAR	(CU.M)	RETURN PERIOD YEAR	(CU.M)
2	7.330	5	3.868
10	2.557	15	2.003
20	1.671		

2.3 Developability of Ground Water

2.3.1 Ground Water Potential

(1) Previous Studies

No detailed assessment of ground water in Su Ngai Golok has previously been made by PWA and DMR.

The Golok River Basin Development Study covers water resource development throughout the Golok River catchment area. The Bang Nara Irrigation and Drainage Project (JICA) studied the flood plain area north of Su Ngai Golok.

These reports describes potentiality of ground water adequate to evaluate it in Su Ngai Golok.

(2) Hydrogeology

The study area comprises two typical aquifers; granitic aquifer and colluvial aquifer. Deep ground water in the colluvial aquifer are confined (Refer to Figure 2-3-1). Deep ground water confined can be drawn by tube wells, while shallow ground water unconfined can be drawn by hand-dug wells.

(a) Granitic Aquifer

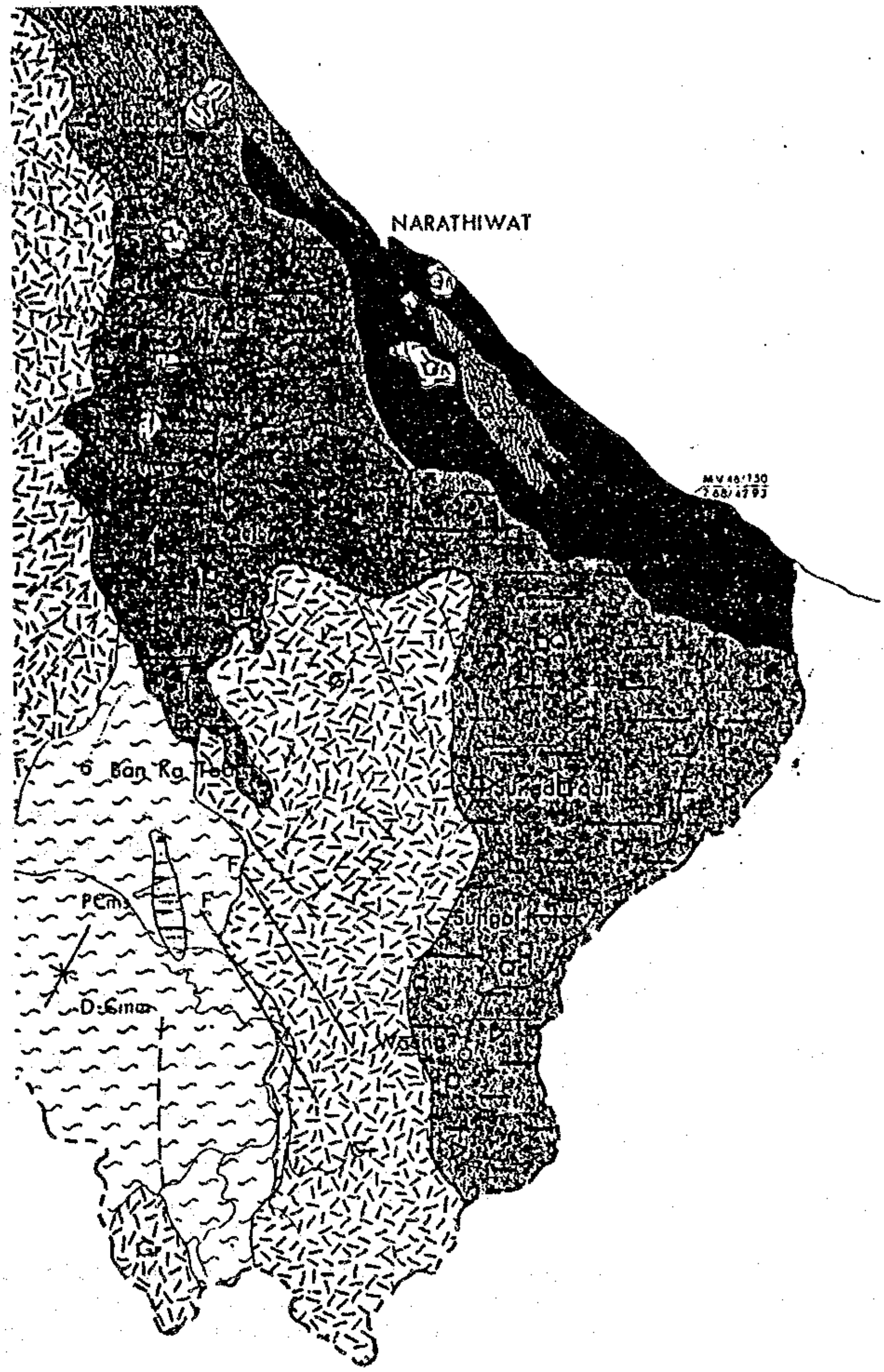
Granite cannot constitute an aquifer in the fresh zone, but store primarily deep ground water in the weathered zone, cracks and faults.

Granite is distributed over the southwest of Su Ngai Golok. Since the diluvial aquifer is not a good aquifer, there may be a little possibility for drawing water from the weathered zone of the granite layer distributed beneath the colluvium.

(b) Colluvial Aquifer

Characteristics

Shallow ground water having the water level between GL -1 to -8 m is exclusively distributed in the study area. This ground water is considered to be the rain water stored in cracks generated as the result of drying and contracting. Most of shallow wells in this aquifer are often dried up during the dry season.



LEGEND

Qcl ; Colluvial Aquifers
Qcp ; Alluvial Aquifers
(Chao Phraya)
Gr ; Granite Aquifers

Source : DMR

FIGURE 2-3-1

HYDROGEOLOGICAL MAP

Quality

- Shallow Ground Water

  Locally, it can be contaminated by household refuse and animal manure. Its chemical composition as pH are affected by the mineral content of the surface clay layer.

  Salinity is rarely detected and pH ranges from 3.2 to 7.0 reflecting the acidic environment imparted the upper clay layer.

- Deep Ground Water

  Deep ground water generally contains iron, salinity and some chemical components.

  The concentrations of iron from 0.14 to 8 mg/l, so water must be treated by aeration and filtration prior to use for water supply.

Water Levels

- Shallow Ground Water

  Static water level in shallow wells ranges from 0.4 to 2.0 m below the ground level.

  Throughout the year water levels fluctuate about 1 m and the water level fluctuation is slightly irregular because of local effect.

- Deep Ground Water

  Static water level in the deep well ranges from 0.2 m above to 5.8 m below the ground level.

  The water level is generally fluctuated less than 2.0 m.

2.3.2 Developability of Ground Water

(1) Shallow Ground Water

Shallow ground water can be developed by private households for their own use but can not be developed for public water supply because of unreliable quantity in the dry season and contamination throughout the year.

(2) Deep Ground Water

The potential yield from the colluvial aquifer could be probably developed from the alluvium adjoining the Golok River within 2 km downstream of the Municipality.

3. EXISTING WATER SUPPLY SYSTEM

3.1 Existing Water Supply System

3.1.1 General

The waterworks for the Municipality of Su Ngai Golok was founded in 1964. The treatment plant had a capacity of 20 cu.m/h and took raw water from the Golok River flowing along the borderline of Malaysia. In 1969, the treatment capacity was expanded to 180 cu.m/h with the construction of the 160 cu.m/h new treatment plant. The waterworks was placed under the control of the PWA and under the jurisdiction of the PWA Regional Office 5 in Songkhla.

Recently, the waterworks purchased the site for the new intake station 7 km upstream from the existing intake point because of deteriorating quality of water in the Golok River.

3.1.2 Treatment

Though there are two treatment units with capacities of 20 cu.m/h and 160 cu.m/h, respectively, the small and old plant has no longer been used because of aging. Elements comprising the treatment plant are summarized in Table 3-1-1.

The raw water taken from the Golok River is pumped through the 300 mm pipe and is fed into the 160 cu.m/h treatment unit. The treatment process consists of chemical flocculation, sedimentation, rapid sand filtration and chlorination. Clear water that is stored in the 1,500 cu.m clear water reservoir is pumped into the 250 cu.m elevated water tank and is distributed to the service area. Backwash water for the rapid sand filters is obtained from a pipeline connected to the elevated water tank.

Figure 3-1-1 provides the schematic layout of the treatment plant.

Table 3-1-1 Outline of Water Treatment Facilities

Water Source	the Golok River
Treatment Capacity	160 cu.m/h.
Treatment Facilities	
Raw Water Pump	150 cu.m/h x 15 m x 28.5 hp x 1 unit engine-driven 295 cu.m/h x 19 m x 40 hp x 1 unit motor-driven 317 cu.m/h x 19 m x 25 hp x 1 unit motor-driven
Rapid Mixing Basin	
No. of Units	2 units
Dimensions	0.97 m x 6.60 m x 0.42 m
Mixing Time	2.0 min.
Flocculation Basin	
No. of Units	2 units
Dimensions	3.00 m x 4.55 m x 2.90 m
Flocculation Time	29.7 min.
Sedimentation Basin	
No. of Units	2 units
Dimensions	3.00 m x 31.35 m x 2.90 m
Sedimentation Time	3.4 hours
Rapid Sand Filter	
No. of Units	4 units
Dimensions	2.90 m x 3.85 m
Filtration Rate	86.0 m/d
Clear Water Reservoir	
No. of Units	1 unit
Capacity	1,500 cu.m
Detention Time	9.4 hours
Water Elevated Tank	
No. of Units	1 unit
Capacity	250 cu.m
Detention Time	1.6 hours
Clear Water Pump	188 cu.m/h x 25 m x 40 hp x 1 unit motor-driven 213 cu.m/h x 25 m x 40 hp x 1 unit motor-driven 167 cu.m/h x 25 m x 18 hp x 1 unit engine-driven 292 cu.m/h x 30 m x 75 hp x 1 unit motor-driven

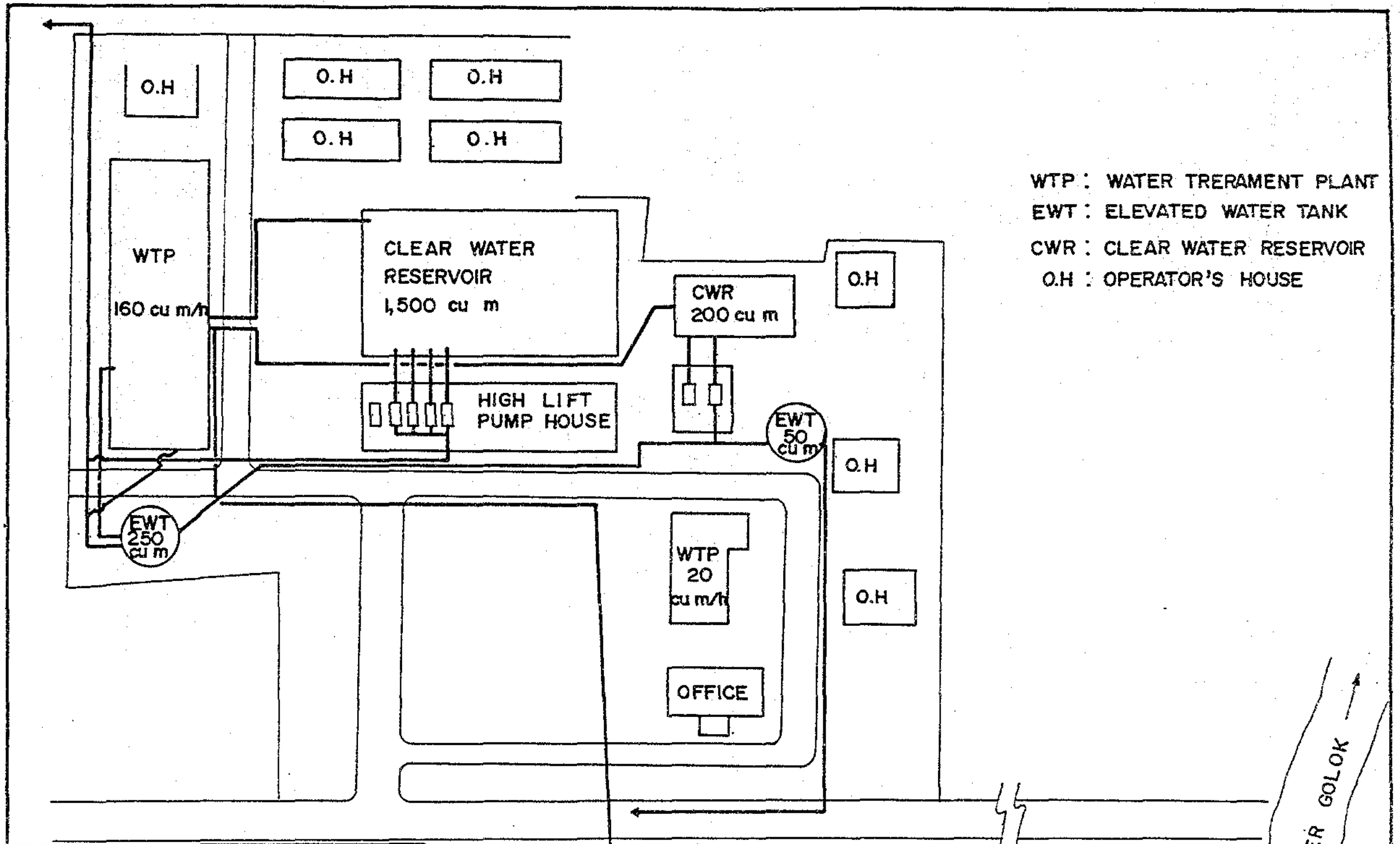


FIGURE 3-1-1
SU NGAI GOLOK EXISTING
WATER TREATMENT PLANT

3.1.3 Distribution System

(1) Description of Existing Distribution System

The distribution system of the Su Ngai Golok Waterworks covers the center of the Municipality as shown in Figure 3-1-2.

The schematic plan of the network is shown in Figure 3-1-3.

Breakdown of the pipeline is tabulated in Table 3-1-2.

Table 3-1-2 Distribution Pipe

Dia. (mm)	Approximate Length (m)	Material
250	1,720	AC
200	1,240	AC
150	5,260	AC
100	10,830	AC
Total	19,050	

Water is pumped up to the elevated tank and then delivered to the services area by gravity. Pumps are turned on and off manually. There are operators who observe the water level of the elevated tank.

The number of connections are as follows:

Table 3-1-3 Number of Connections

Year	No. of Connections
1980	1,531
1981	1,595
1982	1,712
1983	1,926
1984	2,072
1985	2,253
1986	2,366
1987	2,550

Although all of the house connections are metered, some meters seem defective or to have measurement errors.

Another defect is that most of the meters cannot detect small flows of less than 5 l/hr. Therefore, some consumers collect water in pots Figure 3-1-2

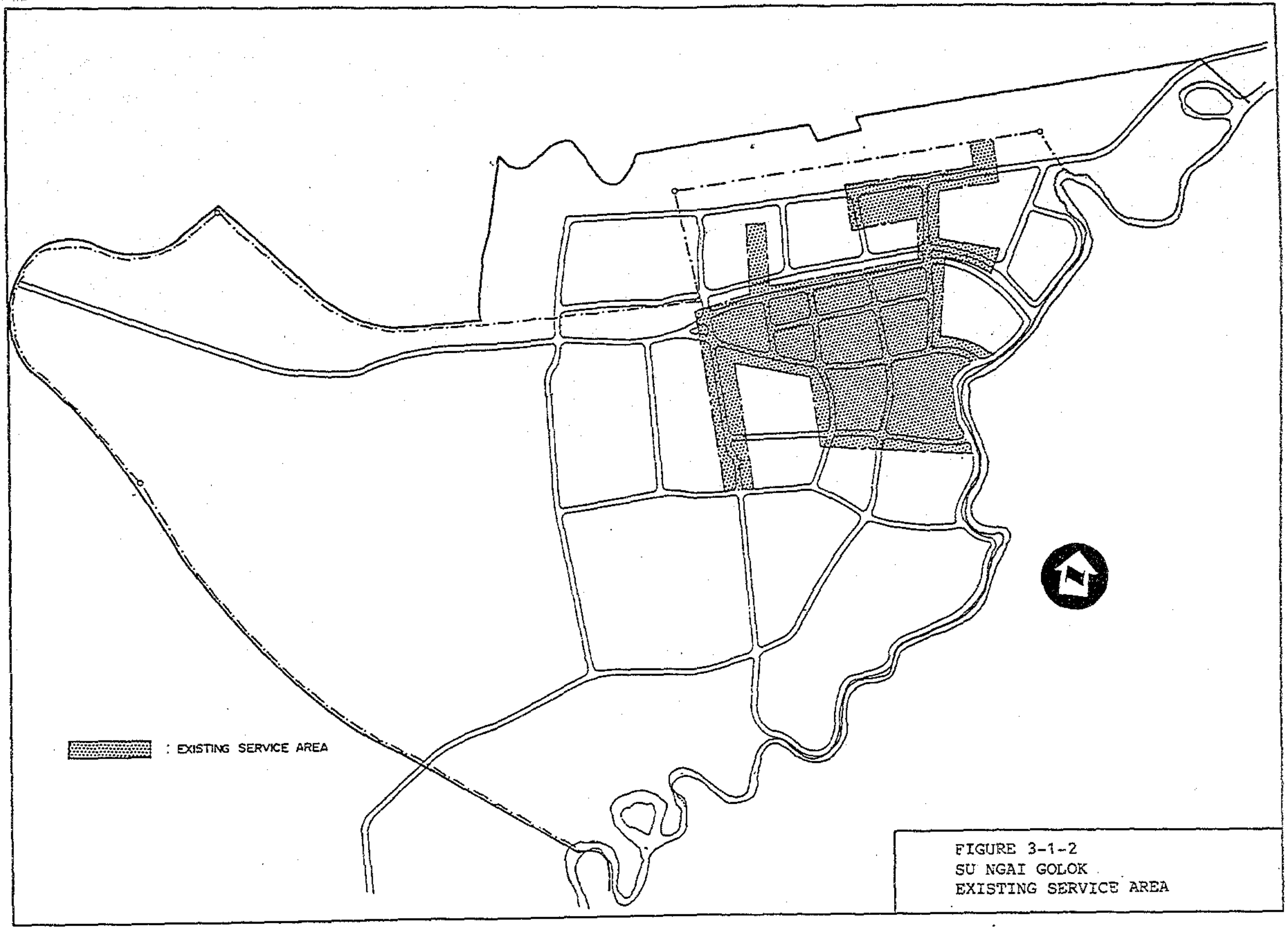


FIGURE 3-1-2
SU NGAI GOLOK
EXISTING SERVICE AREA

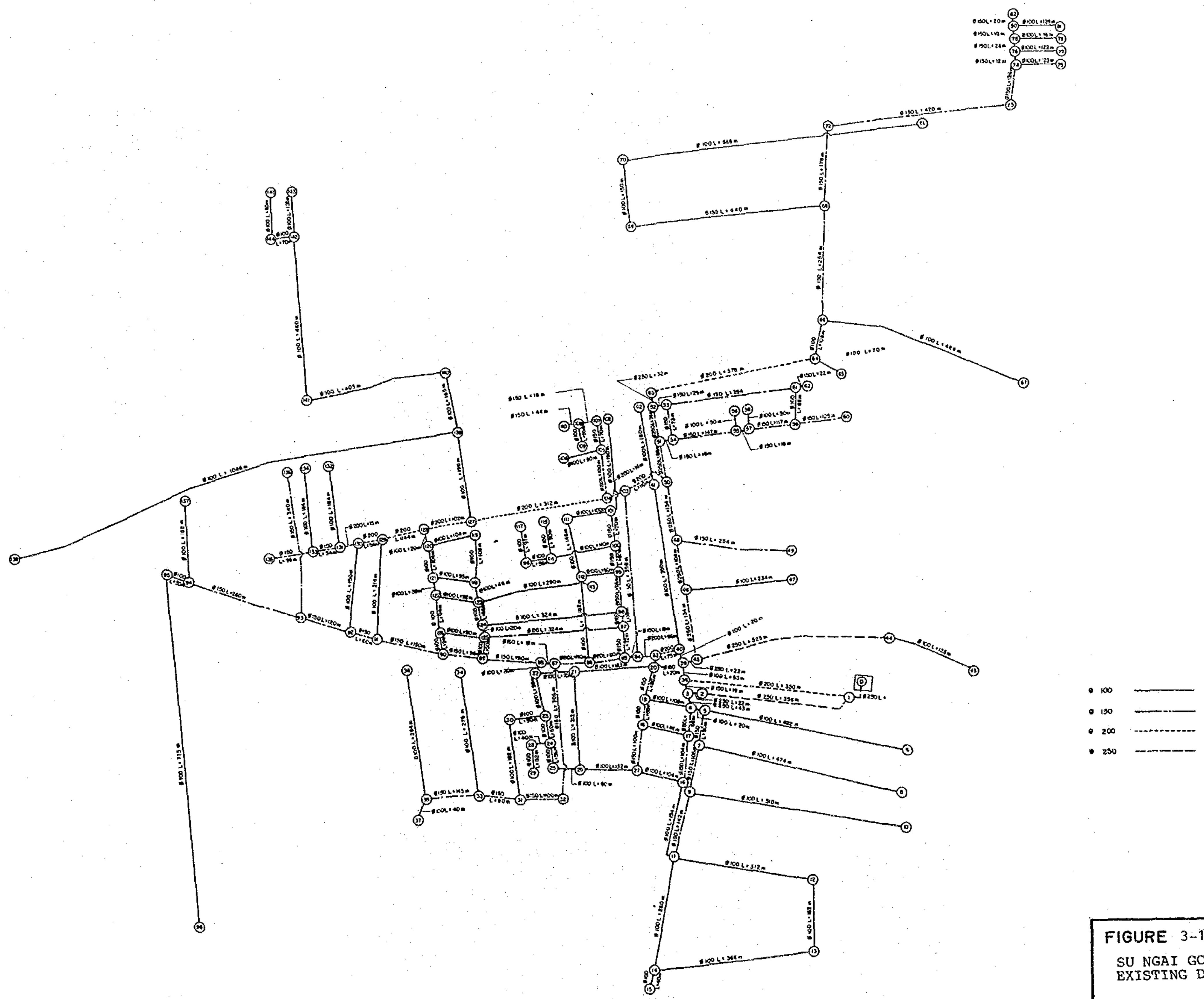


FIGURE 3-1-3
SU NGAI GOLOK
EXISTING DISTRIBUTION NETWORK

or jars just by choking their faucets to the stated level.

The defects of the meters as described above will be reflected when considering the unaccounted-for water.

(2) Distribution Network Analysis

(a) Method of Analysis

A computer model was used to analyze the existing distribution system and to prepare an improvement plan as required. The model uses a stsndard Hardy-Cross network technique where head losses are calculated using the Hazen-Williams equation. An interactive process is used in the model to balance the hydraulic grade line at each pipe junctions in the network, with adjustments made in the hydraulic grade line to satisfy the continuity equation at each junction. The model can accommodate a large number of pipes and multiple sources, reservoirs and pump stations.

(b) Hazen-Williams Discharge Coefficients ("C" values)

Estimates of the Hazen-Williams discharge coefficients for existing pipelines are made based the age of pipes which was obtained from the Su Ngai Golok Waterwork during the field survey. Although the C value for asbestos cement pipes usually remains at 110 or close to its original level, newly installed pipes in the past 2 to 3 years use a C value of 110, and a C value of 100 is adopted for other remanning pipes.

(c) Demand distribution

Based on the water sales records, a demand distribution at each node was prepared. It was assumed for the purpose of initial analysis that the existing treatment plant can supply enough treated water to meet the daily and hourly maximum water demands.

(d) Evaluation of the Existing distribution system

Using the data described above, a simulation was made to the existing system by the computer model described earlier. This simulation shows that a pressure of about 25m in water column is required at the existing treatment plant. The results indicating pressure contour lines are shown in Figure 3-1-4. The computer output of distribution network analysis are presented in the separate volume.

Figure 3-1-4 indicates a low pressure area where the pressure is less than 10kg/sq.cm., and such an area covers about two third of the existing service area.

The results of the pressure measurement in the distribution system described in Appendix A-3-1 also confirm such an low pressure area and identified by the waterworks official.

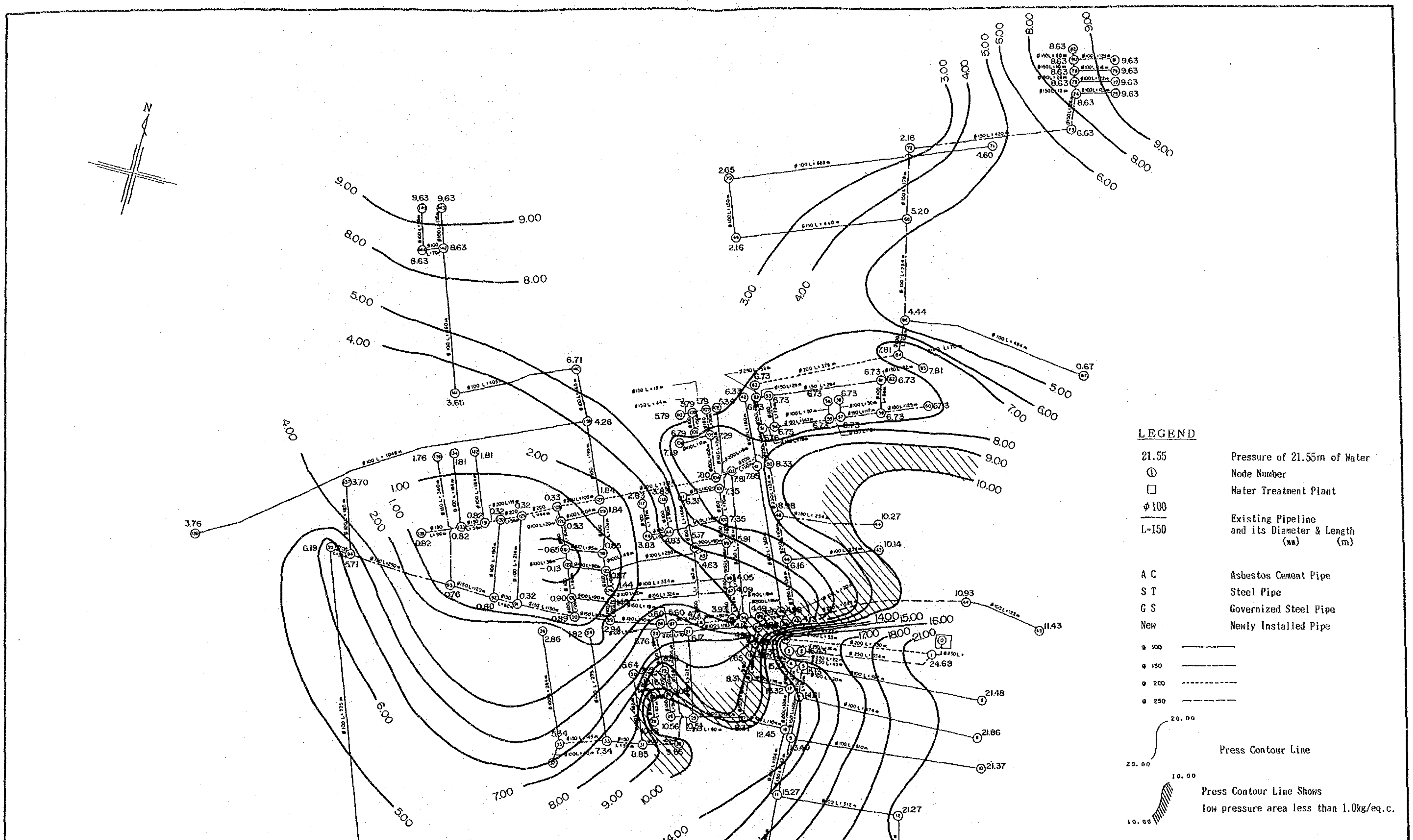


FIGURE 3-1-4
PRESSURE CONTOUR LINE

3.1.4 Immediate Improvement Plan

To solve a low pressure area described in Section 3.1.3, some of the existing pipelines are recommended to be replaced.

Figure 3-1-5 indicates the replacement of pipes and the results of distribution system analysis to cope with the hourly maximum flows with sufficient service pressure except for the high ground elevation area, are presented in the seaparate volume.

Breakdown of the replacement of the pipes are tabulated in Table 5-2-1.

Table 3-1-4 Distribution Pipelines for Repacement

Node No.		Dia. (mm)		Length
From	To	Existing	Improvement	
4	19	100	150	108
38	39	100	200	53
39	40	100	150	20
64	66	100	150	108

3.2 Operation and Maintenance

The operational status for the past one year, from October 1986 to September 1987, is shown in Table 3-2-1.

The monthly water production, before deducting the amount of clear water used in the production system, averages 166.8 cu.m/h with a maximum of 188.0 cu.m/h and a minimum of 147.1 cu.m/h. The maximum exceeds the treatment capacity of 160 cu.m/h by 17.5%.

The treatment loss is 4.7 percent which is at reasonable level. There are a few reversal in figures between the water distribution and sales data such as in 1986, and May and August 1987.

The average monthly alum dosage rates are within a narrow range of 8.8 mg/l and 19.1 mg/l, while the optimum alum dosage rate is between 10 mg/l and 15 mg/l according to the results of the jar test. If there is no significant change in water quality between the last year and this year, the present dosage rate is at the proper level.

Lime addition for pH control is done throughout the year and the dosage rate is in the range of 0.2 mg/l and 0.9 mg/l.

The cleaning of sedimentation basins is conducted periodically, or every three months, while the backwash of the rapid sand filters is done once daily. Mud balls and uneven surfaces are found in all the filters.

Table 3-2-1 Operational Record (Oct. 1986 - Sep. 1987)

Item	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	Ave
A) Raw Water	118518	114578	111531	113902	112978	129990	141020	136575	138884	140975	134173	127921	1521045	126754
Ground Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Surface Water	118518	114578	111531	113902	112978	129990	141020	136575	138884	140975	134173	127921	1521045	126754
*Variation	0.935	0.904	0.880	0.899	0.891	1.026	1.113	1.077	1.096	1.112	1.059	1.009	-	-
B) Raw Water Used	2307	4264	2124	2988	2332	6068	5668	4967	9728	11300	3938	4092	50776	4081
Sedimentation Basin	347	0	0	673	0	779	0	0	872	0	0	575	3246	271
Drainage	1960	4264	2124	2233	2206	5124	5320	4935	8673	11228	3850	3444	55361	4613
Waste	0	0	0	82	126	165	348	32	183	72	88	73	1169	97
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0
*(B)/(A)	0.019	0.037	0.019	0.026	0.021	0.047	0.040	0.036	0.070	0.080	0.029	0.032	0.039	-
C) Treated Water	116211	110314	109407	110914	110646	123922	135352	131608	129156	129675	130235	123829	1461269	121772
*Variation	0.954	0.906	0.898	0.911	0.909	1.018	1.112	1.081	1.061	1.065	1.069	1.017	-	-
D) Treated Water Used	5013	5040	2847	4144	3840	7153	9698	6075	10223	9650	1158	4098	68939	5745
Filter Washing	3941	4914	2695	3696	3717	5817	9275	5880	9450	9457	1050	3556	63448	5287
Chemical Mixing	30	58	43	35	30	87	113	75	90	58	53	35	707	59
Engine	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sedimentation Basin	560	0	0	315	0	563	0	0	533	0	0	439	2410	201
Clear Water Reservoir	450	0	0	0	0	0	0	0	0	0	0	0	450	38
Elevated Water Tank	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Used in Area	32	68	109	98	93	686	310	120	150	135	55	68	1924	160
Used in Houses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
*(D)/(C)	0.043	0.046	0.026	0.037	0.035	0.058	0.072	0.046	0.079	0.074	0.009	0.033	0.047	-
E) Distributed Water	110456	105274	106560	106770	106806	116769	125654	125533	118933	120025	125159	119731	1387070	115630
*Variation	0.955	0.910	0.921	0.923	0.924	1.010	1.087	1.086	1.028	1.038	1.082	1.035	-	-
F) Sold Water	96952	107557	93510	101811	98612	102177	109876	131080	91816	102119	129027	101690	1266227	105519
Connection Meters	96932	107533	93499	101767	98501	102083	109692	131015	91794	102091	129004	101682	1265593	105466
Public Meters	20	24	11	44	111	94	184	65	22	28	23	8	634	53
Lump Sum	0	0	0	0	0	0	0	0	0	0	0	0	0	0
*Variation	0.919	1.019	0.886	0.965	0.935	0.968	1.041	1.242	0.870	0.968	1.223	0.964	-	-
G) Unaccounted-for Water	13504	-2283	13050	4959	8194	14592	15778	-5547	27117	17906	-3868	18041	121443	10120
*(G)/(E)	0.122	-0.022	0.122	0.046	0.077	0.125	0.126	-0.044	0.228	0.149	-0.031	0.151	0.088	-
H) No. of Connections	NA	2389	2388	2437	2442	2464	2492	2508	2524	2532	2541	2550	-	-
I) Per Conn. Consumption	NA	46.18	45.82	45.51	45.31	50.29	54.31	52.48	51.17	51.21	51.25	48.56	542.10	49.22
*Variation	NA	0.937	0.930	0.924	0.919	1.021	1.038	1.065	1.038	1.039	1.040	0.985	-	-
J) Chemical														
Alum	1625	1650	1525	1525	975	1325	1650	1750	2275	2475	1700	2075	20550	1713
Bleaching Powder	540	560	560	560	560	760	520	680	680	620	500	500	7040	587
Chlorine Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lime	96	136	66	64	96	64	64	24	67	40	40	75	832	69
K) Chemical Dosage Rate														
Alum	13.98	14.96	13.94	13.75	8.81	10.69	12.19	13.30	17.61	19.09	13.05	16.76	-	14.06
Bleaching Powder	4.65	5.08	5.12	5.05	5.06	6.13	3.84	5.17	5.26	4.78	3.84	4.04	-	4.82
Chlorine Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00
Lime	0.83	1.23	0.60	0.58	0.87	0.52	0.47	0.18	0.52	0.31	0.31	0.61	-	0.57

Note: The unit, if not specified, is a cu m and the marked items (*) are dimmensionless.

3.3 Existing Improvement/Expansion Plan

3.3.1 Improvement/Expansion Plan for Treatment Plant

A detailed design was prepared for the improvement of the existing sedimentation basin and the sand filters at the Su Ngai Golok Waterworks in order to increase its treatment capacity from 160 cu.m/h to 240 cu.m/h.

The improvement works include the following:

(1) Sedimentation Basin

a) Removal of existing inlet drop pipes and baffle walls;

b) Provision of flocculation channels (for hydraulic flocculation);

c) Provision of perforated baffle walls at the end of flocculation channel and after the 180 degree bend;

d) Provision of invert concrete at the bottom to make the bottom hoppers' slope steeper;

e) Provision of connection holes between the two basins;

f) Provision of a flow rate measuring board;$and

g) Provision of outlet troughs.

Out of the seven components, items b) and e) should be carefully considered and studied. The item b) work is to enable efficient flocculation prior to the sedimentation process. The flocculation will be made while water flows through the round-the-end type baffle walls.

The efficiency of the flocculation is evaluated by calculating the velocity gradient (G) for the flocculator from the equation developed by Camp and Stein as shown below:

$$G = (Q\ gh/\mu V)^{1/2} = (\ gh/\mu t)^{1/2}$$

Where,

G = velocity gradient (s^{-1})
 = density of water (kg/cu.m)
h = head loss (m)
μ = dynamic viscosity (kg/m.s)
t = detention time Q/V (s)
Q = flow rate (cu m/s)
P = power Q gh (watts, $kg.m^2/s^3$)
V = volume of unit (cu.m)
g = gravitational constant (9.81 m/s^2)

The most effective range of G and Gt values is recommended as below:

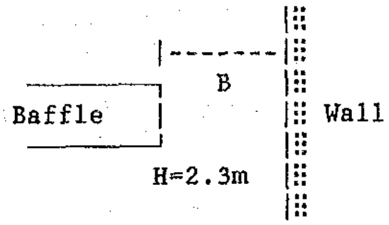
Type	Velocity Gradient G (s^{-1})	GT
Turbidity or color removal (w/o solids recirculation)	20-100	20,000-150,000
Turbidity or color removal (w/ solids recirculation)	75-175	125,000-200,000
Softeners (solids contact reactors)	130-200	200,000-250,000

Source : Smethurst, G., (1979) Basic Water Treatment for Application Worldwide, Thomas Telford Ltd., London

From the design drawings, G and Gt values are calculated as below:

Design flow rate : Q = 240 cu.m/h (for 2 lines)
= 120 cu.m/h (for each basin)
= 0.0333 cu.m/s

Head loss at the baffle



	1	2	3
B	0.031	0.051	0.102
No(n)	9	9	9
A(=BH)	0.071	0.117	0.235
h	0.450	0.165	0.041

$h = \Sigma H = 0.656$ m

$h = k\,(v^2/2g) \times n$

$k = 2.5$

Volume of unit

V = (L) 8.8 x (w) 3.0 x (D) 2.3 - (baffle volume 6.6 cu.m)
= 54.1 cu.m

V/Q = 54.1/0.0444 = 1,219 sec

Assuming Temperature : 25 C°

= 997.1 (kg/cu.m)

$\mu = 0.0089$ (kg/m.s)
$G = (997.1 \times 9.81 \times 0.656/0.0089 \times 1219)^{1/2} = 24.3\ (sec^{-1})$

Gt = 29,600

These figures fall into the desirable range.

For the item e) in the improvement works, it should be determined whether one basin should be emptied and cleaned up since provision of open holes in the partition wall will make it impossible to empty one basin.

(2) Sand Filter

a) Provision of surface wash pipe
b) Modification of underdrain system
c) Modification of backwash system

These modifications are to improve the efficiency of the sand filters and to double their filtration capacity.

These three works are to improve the purpose for which the plants were designed.

3.3.2 General Concept of PWA for Improvement/Expansion for Water Treatment Plant

PWA's general concept for the improvement and expansion of the water treatment plant is based on the recommendations of the UNDP experts, which are summarized in the article "Improving Water Supply in Thailand" by Messers. Sawasdi Orvichian, Prasert Chuaphanich, and Susumu Kawamura, Journal of AWWA, Management and Operations, June, 1988.

The concept for improvement and expansion was established to increase the treatment capacity without the addition of new basins and filters. The modification for improvement consists of three phases as listed below:

Stage 1 - Correct existing deficiencies and implement those modifications needing immediate action.

Stage 2 - Expand plant capacity at the earliest possible time.

Stage 3 - Modernize plants and improve safety.

These stages were separated in accordance with the urgency of the measures to be taken, and the cost-effectiveness of the investment.

At present, PWA is implementing the improvement and modification program for the various waterworks systems and is applying the technology recommended for Stage 1. The facilities and measures for improvement are summarized below:

(1) Coagulation System (Flush Mixing)

Coagulation and flocculation are the most important processes in the treatment system. As most of the existing plants have no proper coagulation and flocculation systems, the sedimentation tank does not work well so that a lot of micro floc are carried over to the sand filter. The proposed improvement is the provision of an in-line static mixer in the raw water main to achieve the proper magnitude of mixing of coagulant.

(2) Flocculation System

Flocculation is a process that is lacking in most of the plants. The recommended flocculation process consists of round-the-end, and flow-type baffled channels (hydraulic flocculation). A mechanical flocculation is not considered here because of the unavailability of spare parts and technical manpower to maintain the system.

(3) Filtration Process

Filters require a wide range of modification. The existing underdrains, gravel beds, filter beds, wash troughs, backwash system and piping should be replaced and improved/modified. To be newly installed is a surface wash system. These modifications may increase the system's treatment capacities by 100%. Dual media filtration is not considered because of the high cost of anthracite.

(4) Sedimentation process

Recognized as the most serious problem in operation is sludge removal. However, sludge withdrawal can be efficiently done by manual cleaning. Therefore, no major modification is considered. Baffled walls are recommended to be installed at the inlet and at the intermediate point to prevent a short circuit of flow. For overflow troughs, the installation of additional troughs is recommended to decrease weir load and to decrease the carry-over of micro floc. Although the recommendations stated above are the basis of the improvement/expansion works, the modification works for the existing water treatment plant are similarly designed.

Stage 2, Expansion of the plant capacity will follow the modification works. After modification works are made, the plant will be expected to have larger treatment capacity or twice the original design rate. Therefore, the amount produced will be able to cope with the increased water demand.

Stage 3, Modernization consists of the preparation of proper instrumentation and safety provisions. This stage is recognized as the final step of modification; therefore actual implementation will not be made until after Steps 1 and 2 are completed. There are also budgetary constraints in the implementation of the improvement/expansion program.

3.4 Existing Constraints

During an intensive field survey, the following constraints on the existing water supply system are reported:

(1) Water Source

The Golok River is polluted by wastewater in Su Ngai Golok.

- Shallow wells are often contaminated by flood or wastewater.

- Deep well water contains iron and sulfide.

(2) Intake and Raw Water Transmission Pipe

- Located just downstream of the wastewater outlet.

- Frequently flooded.

(3) Treatment

- Treatment can not meet the amount of intake in short time, so it is frequently overlooked in operation.

- Mud balls are found in filters.

(4) Distribution

- Pipeline does not form efficient network, and has dead ends in some lines.

(5) Operation and Maintenance

- Intake operation was not necessarily made to meet the treatment capacity.

3.5 Organization

3.5.1 Organization of Regional Office

The regional offices of PWA directly supervise the urban waterworks and assist the rural waterworks in technical aspects.

The Su Ngai Golok Waterworks is supervised by the Regional Office V in Songkhla which covers 15 waterworks in this region. Figure 3-5-1 shows the organization chart of the Regional Office V. The function of each section is described as follows:

(1) Personnel & Clerical Section

This section is responsible for personnel administration of the waterworks, including the training of waterworks personnel.

(2) Finance & Accounting Section

A charge of finance and accounts of the waterworks including borrowing and depositing at their bank accounts.

(3) Procurement and Stores Section

This section takes charge of procuring and storing materials and supplies necessary for operating water supply facilities of the waterworks.

(4) Maintenance Section

This section gives guidance and instruction on the conduct of the operation and maintenance of the waterworks facilities.

(5) Technical Service Section

A preliminary survey of projected waterworks schemes for both urban and rural waterworks is provided by this section.

(6) Water Quality Control Section

This section is responsible for conducting the water quality analyses of both raw and treated water.

(7) Survey Section

This section is responsible for providing the Head Office with information concerning rural waterworks and planning new water supply projects.

(8) Price Estimation Section

This is responsible for estimating the expansion/ rehabilitation cost of water supply systems for both urban and rural waterworks and for preparing documents, drawings and others for bidding.

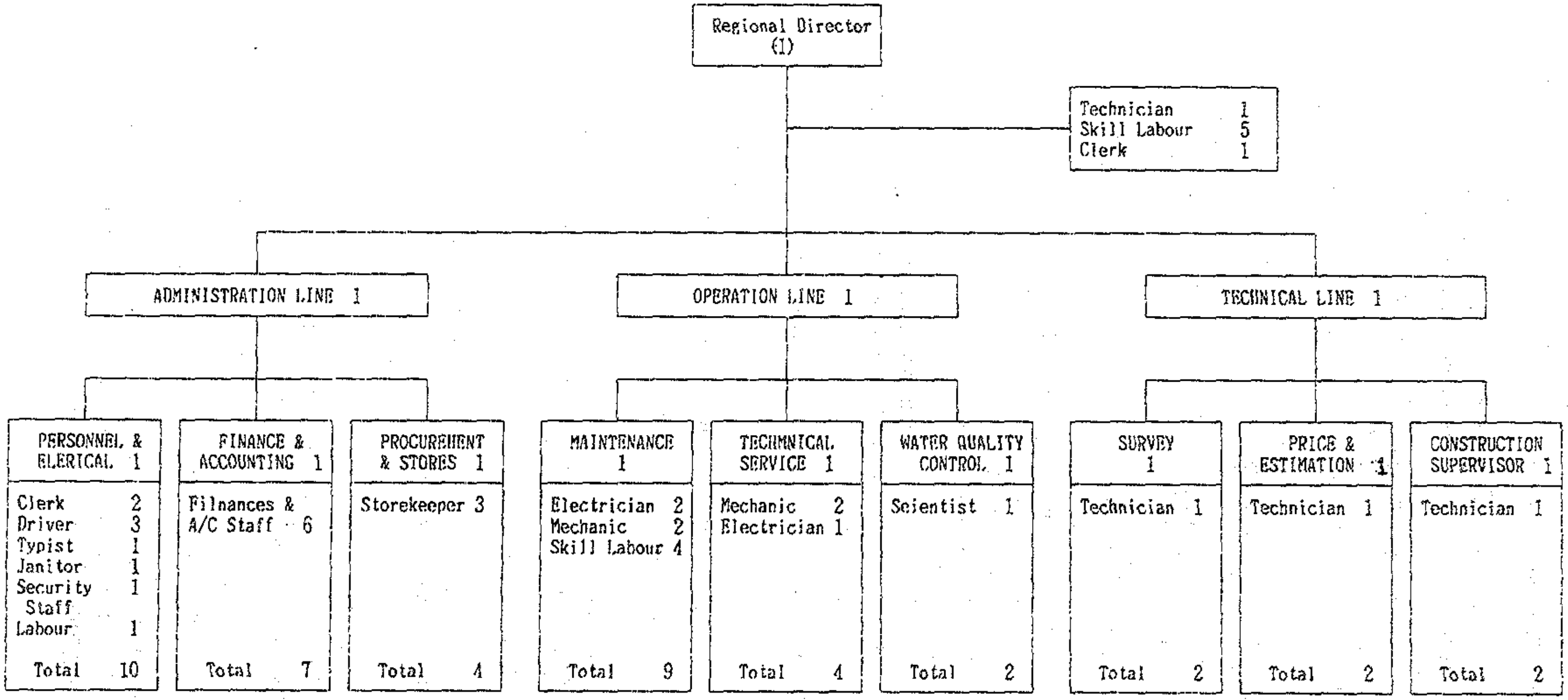


FIGURE 3-5-1
ORGANIZATION CHART OF
REGIONAL OFFICE 5

(9) Construction Supervision Section

This is responsible for supervising the construction and expansion/rehabilitation works of water supply facilities.

3.5.2 Organization of Waterworks

The organization of the Su Ngai Golok Waterworks consists of three sections;$namely, the production, services, and administration sections. The organization chart showing the number of employees is shown in Figure 3-5-2, and the function of each section is described as follows:

(1) Water Production Section

This section is responsible for operation and maintenance of water production facilities.

(2) Service Section

Services of setting and repairing house-connections are provided by this section.

(3) Administration Section

This section takes charge of meter reading and bill- collection, book-keeping of customers accounts, financing, record-keeping of waterworks income and expenditure, and other administrative works and meters.

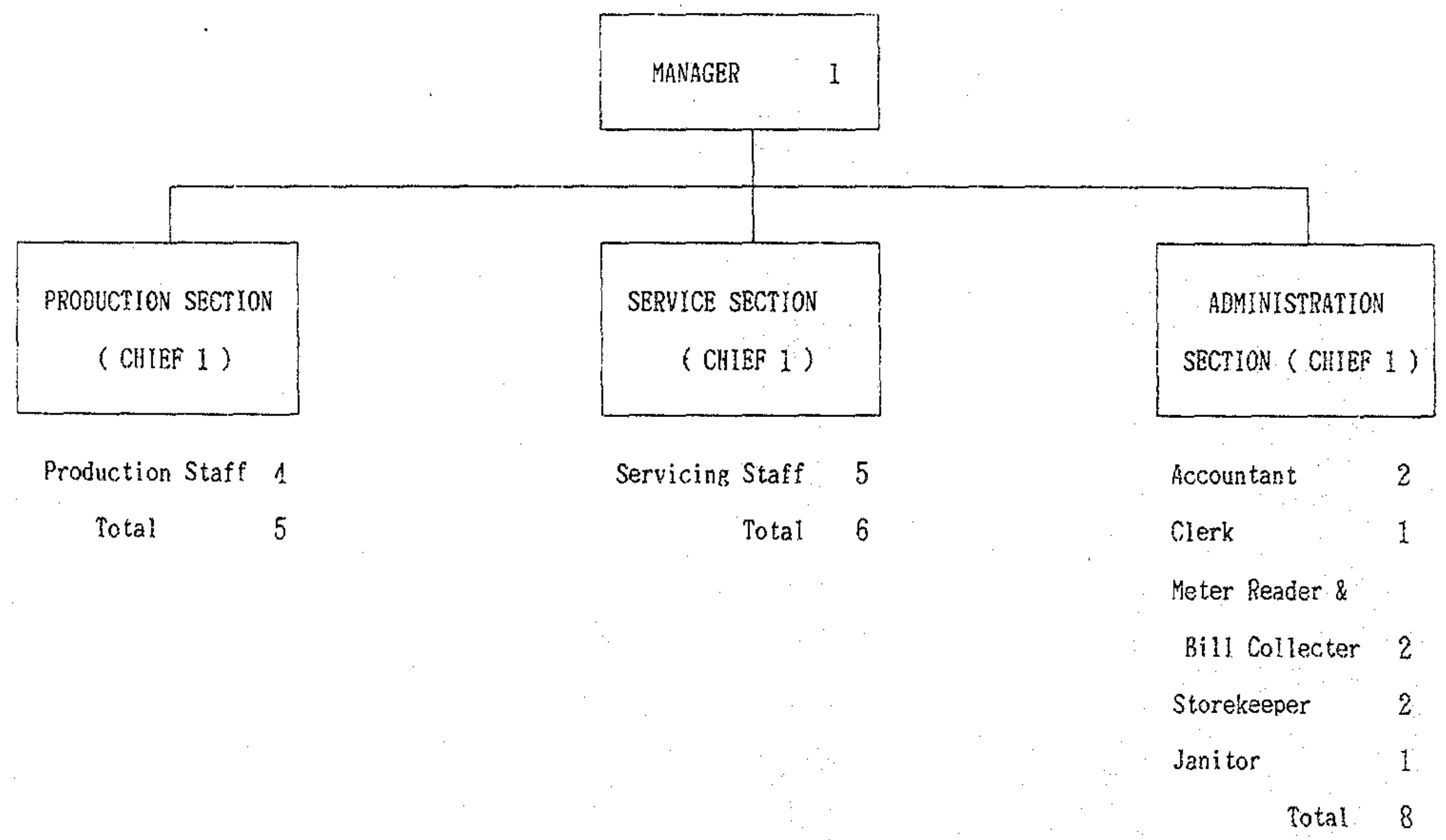


FIGURE 3-5-2
ORGANIZATION CHART OF
SU NGAI GOLOK WATERWORKS

3.6 Financial Status

3.6.1 Present System

As of 1987, Su Ngai Golok Waterworks has 2,550 connections. During the same year, water production was 1,266,207 cu.m while water sale was 1,461,269 cu.m/d.

PWA has three major sources of tariff revenue: namely water sales, service charges and connection fees, the deatails of which are described in Section 17.1.

3.6.2 Revenue and Expenditure

The annual revenue and expenditure of the waterworks in the last three years are shown below:

Table 3-6-1 Revenue and Expenditure

(Unit : 1,000 ฿)

Year	Revenue	Expenditure	Profit(Loss)
1985	7,139	2,726	4,413
1986	9,241	2,502	6,739
1987	10,029	2,778	7,251

The accounting system of the PWA provides that all the revenues of the waterworks are transferred to the PWA Head Office. All the expenses are also allocated by PWA Head Office. However, as shown in Table 3-6-3, such accounts as capital investment, debt service and depreciation and amortization are not included in the waterworks' financial system.

To identify and quantify the financial status of waterworks, one of the financial ratios (revenue/expenditure) is computed as shown below:

Table 3-6-2 Ratio of Revenue and Expenditure

Office	1985	1986	1987
PWA Head Office	1.45	1.72	1.76
Su Ngai Golok Waterworks	2.62	3.69	3.61

When the this ratio is equal to or greater than 1.0, the water system's financial status is considered to be in good condition.

As shown above, the waterworks earned a net profit on its annual operations. Also, the ratio is greater than average rate of PWA all waterworks.

A breakdown of the revenue and expenditure is shown in Table 3-6-3.

Table 3-6-3 Revenue and Expenditure of Su Ngai Golok Waterworks

(Unit : Baht)

Description	1985	1986	1987
Water Production cu.m	1,527,501	1,374,478	1,461,269
Water Sales cu.m	1,081,895	1,158,101	1,266,207
No. of Connections	2,253	2,366	2,550
Revenue			
Water Sales	6,101,536.80	8,348,456.01	9,157,830.25
Service Charge	337,185.00	355,465.00	372,900.00
Connection Fee	663,561.00	513,557.00	475,400.00
Other Revenue	36,478.64	23,642.71	22,471.99
Total Revenue (A)	7,138,761.44	9,241,120.72	10,028,602.24
Expenditure			
Salaries	1,249,800.00	1,303,290.00	1,438,440.00
Remuneration	206,829.79	197,801.94	230,974.28
Chemical	136,524.90	130,342.10	163,533.50
Material & Maintenance	195,534.89	89,343.40	108,491.25
Oil & Fuel	38,244.10	29,168.30	24,102.65
Office Supplies	14,198.57	20,227.48	18,340.87
Hired Service	12,668.90	28,561.00	35,385.10
Other Operating Expense	11,117.00	6,596.00	16,928.00
Public Utilities	6,413.50	17,308.75	8,415.00
Electricity	682,778.24	516,228.37	625,203.84
Connection Cost	168,826.75	160,370.51	104,946.00
Material Sold	3,186.00	2,460.00	3,148.00
Total Expenditure (B)	2,726,122.64	2,501,697.85	2,777,908.49
Profit (Loss)	4,412,638.80	6,739,422.87	7,250.693.75