DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

MINISTRY OF LOCAL GOVERNMENT, HOUSING AND CONSTRUCTION

NATIONAL WATER SUPPLY AND DRAINAGE BOARD

FEASIBILITY STUDY
ON
WATER SUPPLY SCHEME FOR AMPARAI GROUP OF TOWNS

FINAL REPORT

DECEMBER 1982

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Democratic Socialist Republic of Sri Lanka, the Government of Japan decided to conduct a feasibility study on the Water Supply Scheme for Amparai Group of Towns and entrusted the study to the Japan International Cooperation Agency (JICA).

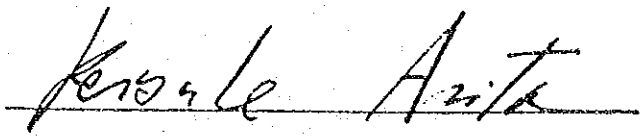
The JICA sent to Sri Lanka a study team headed by Mr. Fujio Ooyama of Nihon Suido Consultants Co., Ltd. from 17th February to 17th May 1982.

The team had discussions with the officials concerned of the Government of Sri Lanka and conducted a field survey in Amparai District. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Scheme and contribute to the promotion of friendly relations between our two countries.

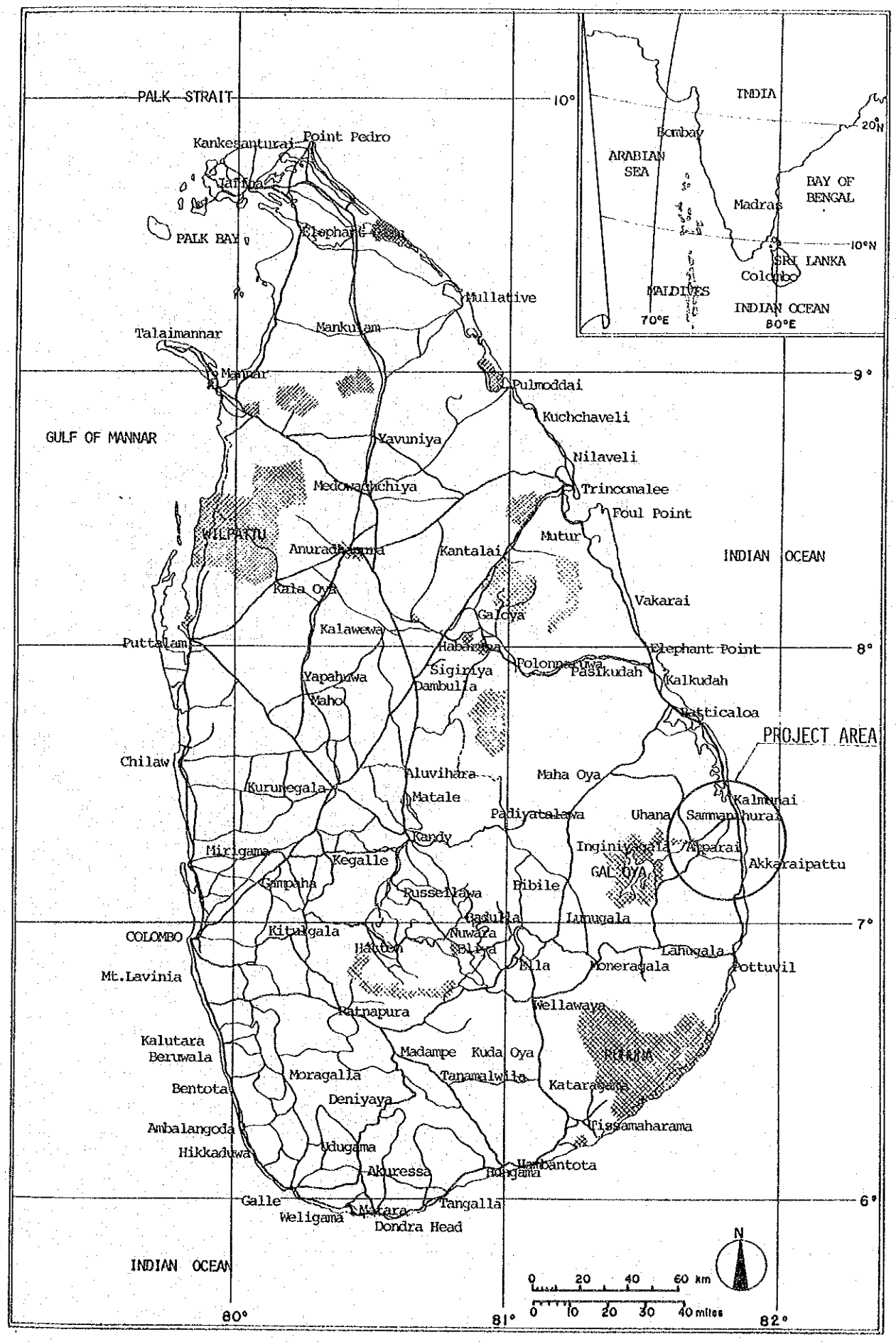
I wish to express my deep appreciation to the officials concerned of the Government of the Democratic Socialist Republic of Sri Lanka for their close cooperation extended to the team.

December 1982



Keisuke Arita
President
Japan International Cooperation Agency

Sri Lanka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Point Pedro
Jaffna
PALK BAY
Elephant Pass
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Talaimannar
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Mannar
9°
Pulmoddai
Kuchchaveli
GULF OF MANNAR
Yavuniya
Nilaveli
Medawachchiya
Trincomalee
Foul Point
WILPATTU
Anuradhapura
Kantalai
Mutur
INDIAN OCEAN
Kala Oya
Vakarai
Galoya
Kalawewa
Puttalam
Habarana
Elephant Point
8°
Polonnaruwa
Pasikudah
Kalkudah
Yapahuwa
Sigiriya
Dambulla
Maho
Batticaloa
PROJECT AREA
Chilaw
Aluvihara
Maha Oya
Kurunegala
Matale
Kalmunai
Padiyatalawa
Uhana
Samanthurai
Kandy
Inginiyagala
Amparai
Mirigama
Kegalle
Akkaraipattu
GAL OYA
Gampaha
Russellawa
Bibile
Gadulla
Lunugala
7°
COLOMBO
Kitulgala
Nuwara
Habarana
Ella
Lahugala
Mt.Lavinia
Koneragala
Pottuvil
Wellawaya
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Beruwala
Madampe
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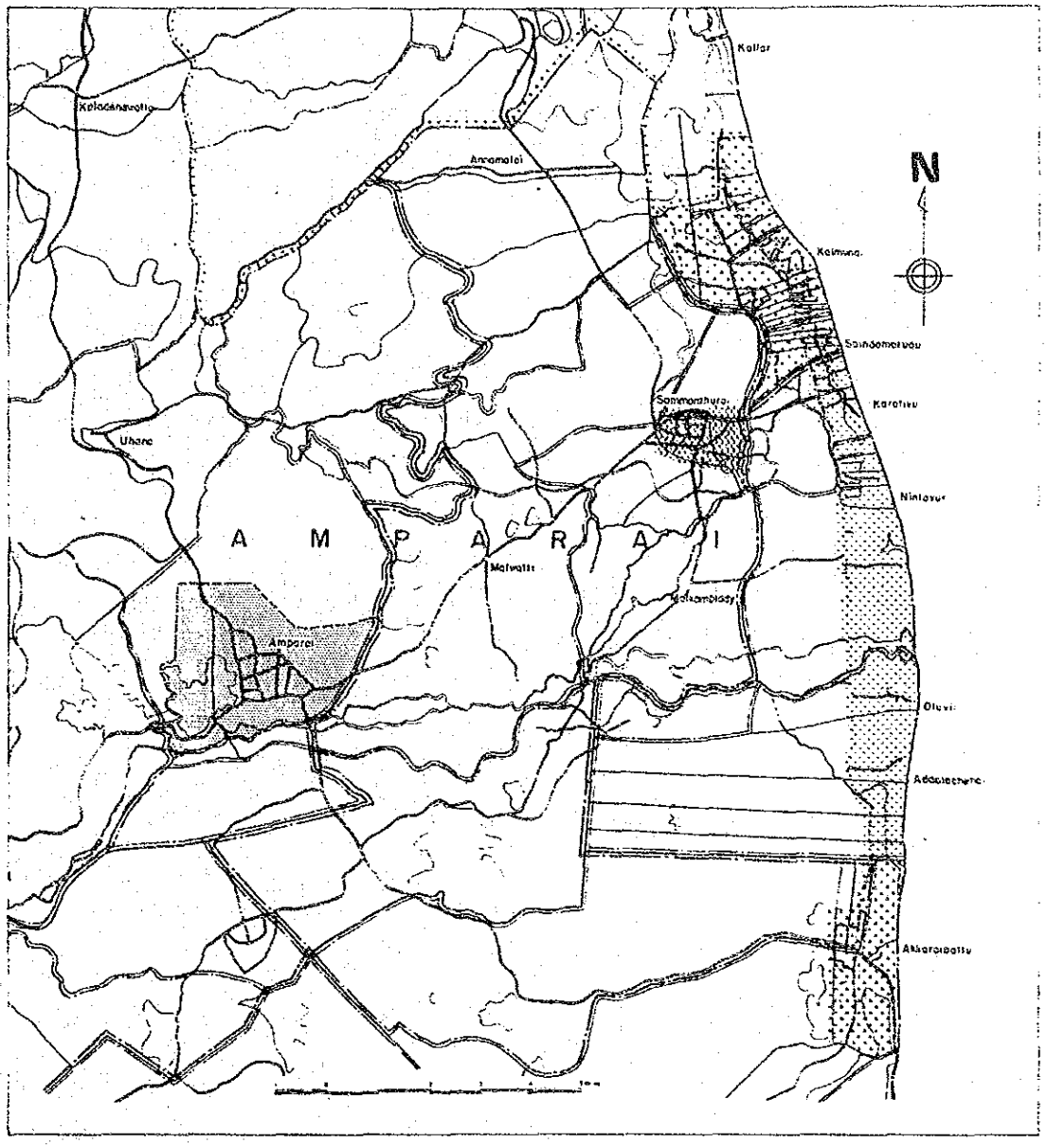
LOCATION OF PROJECT AREA



REFERENCE

+++++ District Boundary

——— D.R.O's Divison Boundary

——— Grama Sevaka Division Boundary

——— Municipal, Urban, Town & Village Council Limits

——— Electoral District Boundary

Remark

Study Area

KALMUNAI + SAINDAMARUDU

AMPARAI U.C.

AKKARAIPATTU T.C.

SAMMANTHURAI T.C.

Coastal area-KARATIVU+NINTAVUR

TABLE OF CONTENTS

ABBREVIATION

millimeter	mm	inch	in. (")
centimeter	cm	foot	ft (')
meter	m	yard	yd
kilometer	km	mile	mi
square centimeter	cm^2	square foot	ft^2
square meter	m^2	square mile	mi^2
square kilometer	km^2	acre	acre
hectare	ha		
cubic millimeter	mm^3	cubic inch	in^3
cubic centimeter	cm^3	cubic foot	ft^3
cubic meter	m^3	cubic foot per sec	cusec
milliliter	ml	gallon	gal
liter	l		
milligram	mg	pound	lb
gram	g		
kilogram	kg		
metric ton	t		
kilograms per square centimeter	kg/cm^2	pounds per square inch	psi
centimeters per second	cm/sec	feet per second	ft/sec
meter per second	m/sec	cubic feet per second	ft^3/sec
cubic meters per second	m^3/sec	gallons per minute	gpm
cubic meters per minute	m^3/min	gallons per hour	gph
cubic meters per day	m^3/d	million gallons per day	mgd
liter per capita per day	lpcd	gallons per capita per day	gpcd
volt	V	ampare	A
kilovolt	kV	kilovolt-ampare	kVA
kilowatt	kW	direct current	DC
revolutions per minute	rpm	alternating current	AC

ORGANIZATIONS

MLGHC	Ministry of Local Government, Housing and Construction
NWSDB	National Water Supply and Drainage Board
JICA	Japan International Cooperation Agency
D.D.C.	District Development Council
U.C.	Urban Council
T.C.	Town Council
V.C.	Village Council
AGA	Assistant Government Agency

CURRENCY EQUIVALENTS

US$ 1.00	=	Rs 20.8	= Yen 250
Rs 1.00	=	US$ 0.048	= Yen 12.0

(as of August 1982)

MEASURES AND EQUIVALENTS

1.0 inch	= 2.54 cm	
1.0 foot	= 30.48 cm	
1.0 mile	= 5,280 ft	= 1.61 km
1.0 sq ft	= 929 cm^2	
1.0 acre	= 4,046.86 m^2	= 0.40 ha
1.0 ac.ft	= 1,233 m^3	
1.0 gal (imp.)	= 4.546 l	
1.0 l	= 0.220 gal	
1.0 cusec	= 0.0283 m^3/sec	= 2,445 m^3/day
1.0 lb	= 0.454 kg	
1.0 lb/in^2	= 0.07 kg/cm^2	

SUMMARY AND RECOMMENDATION

1. Physical and Socioeconomic Aspects

Amparai District is located in the Eastern Province of Sri Lanka. The District has an area of 3,050 km^2, covering the project areas of Amparai Urban and Coastal and extends in a plateau of 30 to 60 m in elevation above mean sea level in Amparai Urban area and 3 to 9 m in elevation above mean sea level in Coastal area. Main features of the Area are as follows:

1) Climates : Annual rainfall; 1,119 mm (40") in 1980
   Average temperature; 28.4 degree in centigrade

2) Population : 183,487 in 1981
   (Total population in D.D.C.; 388,786)

3) Socioeconomic feature :

   Road: paved and maintained by the Highway Dept.

   Electricity: full day supply from the Senanayake hydro-power station

   Water supply system: three existing water supply schemes in operation

   Hospital: two district hospitals

   Public health: preventive measures against infectious diseases by the Public Health Dept.

2. Existing Water Supply

1) Amparai water supply scheme

Design capacity	:	6,500 m^3/d (1.44 mgd)
Present water production	:	2,600 m^3/d (0.59 mgd)
Water source	:	Amparai tank
Population served	:	15,000
Operation	:	NWSDB

2) Kalmunai water supply scheme

Design capacity	:	550 m^3/d (0.13 mgd)
Present water production	:	46 m^3/d, 3 hours supply in a day
Water Source	:	groundwater (shallow well)
Population served	:	10,000
Operation	:	NWSDB

3) Naipuddimunai water supply scheme

Present water production	:	90 m^3/d (0.02 mgd)
Water source	:	groundwater (shallow well)
Population served	:	2,000
Operation	:	Kalmunai AGA

4) Sammanthurai water supply scheme (under construction)

Design capacity	:	2,200 m^3/d (0.5 mgd)

The existing water supply systems of elevated towers and distribution pipelines will be incorporated into the proposed water scheme.

3. Long Range Water Supply Scheme Up To the Year 2005

The proposed service area is divided into two areas considering the geographical feature, viz, Amparai area and Coastal area. The potential water sources, the tanks and anicuts water for each service area, to meet the projected water demand were investigated together with their water quality. Based on the comparative study of five alternatives for the future water supply system, water of Amparai tank is proposed for Amparai area and the Sambuveli anicut water for Coastal area.

The whole scheme is recommended to implement by stagewise construction, Stage-I and Stage-II, considering appropriate magnitude of investment and availability of funds. Stage-I scheme is scheduled to commence in 1983 with the engineering services for detailed design and will be completed in 1986. Stage-II Programme will be commenced in 1991 for

conducting necessary reviews on the future plan including population growth, past records of water consumption and development of each service area.

1) Target year : Stage I : 1995
Stage II: 2005

2) Service area : 2,742 ha in 1995
3,325 ha in 2005

3) Population in service area : 237,100 in 1995
287,800 in 2005

4) Population served : 172,300 in 1995
261,100 in 2005

5) Water demand : 27,400 m^3/d in 1995
53,900 m^3/d in 2005

6) Water source : Amparai tank water for Amparai area and Sambuveli anicut water for Coastal area

7) Project cost estimates :

	Stage I	Stage II	Total
Foreign Exchange	273	239	512
Local Currency	150	142	292
Total	423	381	804

(Unit: Rs million)

4. Stage I Program

1) Target year : 1995

2) Service area : Amparai area: 537 ha
Coastal area: 2,205 ha

3) Population in service area : Amparai area: 28,600
Coastal area: 208,500

4) Population served : Amparai area: 26,300
H: 17,100
S: 9,200
Coastal area: 146,000
H: 65,700
S: 80,300
H: Direct consumers by house connections
S: Indirect consumers by standposts

5) Water demand (Max daily demand) : Amparai area: 5,300 m^3/d (1.2 mgd)
Coastal area: 22,100 m^3/d (4.9 mgd)

6) Per capita consumption : Amparai area: 202 lpcd
Coastal area: 151 lpcd

7) Water source : Amparai area: Amparai tank
Coastal area: Sambuveli anicut

8) Treatment method : Amparai area: dual-stage filtration
Coastal area: rapid sand filtration

9) Project cost estimates :

	Amparai	Coastal	Total
Foreign Exchange	40	233	273
Local Currency	36	114	150
Total	76	347	423

(Unit: Rs million)

10) Proposed implementation schedule : Loan negotiation; 1983
Detailed design ; 1983
Tendering ; 1984
Construction : 1984 to 1986
27 months including test operation

5. Financial Aspect

On the basis of investment program for the proposed project, financial condition is checked by preparing projections of revenue and expenditure. For financing condition, it is intended that grant element is considered heavily for capital works so as to keep at minimum level the water rate. Loan is considered only for half of the distribution facilities of foreign currency portion. As a result of financial projections, it is found that the financial position of the Board would be positive in ten years with average water rates of Rs 1.80/m^3 for the first five years and RS. 2.00/m^3 for the rest of the years.

6. Water Rate

It is essential for NWSDB to raise sufficient revenues to satisfactorily operate and maintain the water supply system constructed. Such revenue should be generated to compensate not only the cost related to physical maintenance of the system but also the financial requirement of debt service payments. After several arrangements of revenue schedule considering factors of grant and loan, an appropriate average water rate was found to be Rs. 1.80/m^3 for the first five years and Rs. 2.00/m^3 for the rest of the years. The water rate distribution by five different categories of consumers is also prepared.

7. Benefits of the Project

The provision of the new water supply system in Amparai will bring several favourable impacts on the present condition of the area. Among others, improvement of area's environmental and sanitation conditions will be great, although these benefit are unquantifiable. Other various economic benefits, including increase of employment opportunity and promotion of commercial activities will also be expected. In the meantime, financial internal rate of return of the project was checked by the present worth method, and rate of return is found 4.91%.

8. Organization and Administration

The modification and strengthening of the Regional Office, Batticaloa, is recommended to undertake necessary construction of the proposed water supply scheme and to control the operation and maintenance of the completed facilities. Such modification requires increment of number of staff in the Regional Office, to be 272 in 1995 and 282 in 2005, respectively.

9. Immediate Improvement of Amparai Water Supply Scheme

The sedimentation basin of Amparai water supply scheme is in need of remodeling; the existing batch-type process should be replaced by the continuous flow type and the flocculation process be provided practising an appropriate dosage of coagulant.

10. Water Rights

For the streamlined implementation of the project, the water rights related to the project should be secured by NWSDB.

11. Financial Provision

NWSDB is requested to arrange necessary provision of funds required for the foreign and local currency portions of the project to initiate implementation according to the proposed schedule.

12. Training of Operational Staff

Training of the present operational personnel is required to maintain satisfactory level of operation and maintenance. In addition, newly recruited personnel are also to be trained under the NWSDB's program.

13. Review of the Future Scheme

The feasibility study of the Stage I scheme is subject to the review, which should be carried out before the start of the detailed design considering changes of socio-economic conditions.

1. INTRODUCTION

1.1 Authorization

The present report on the feasibility study for Amparai Group of Towns Water Supply Scheme is prepared under the terms of the Contract for engineering services between the Japan International Cooperation Agency (hereinafter called the JICA) and Nihon Suido Consultants Co., Ltd. (hereinafter called the Consultants) dated 8th February 1982. The study was earlier requested by the Government of Sri Lanka to the Government of Japan and it was decided later to undertake the study through the JICA within the frame of the international cooperation programme. With regard to execution of the study, the leading agency of the Government of Sri Lanka is the National Water Supply and Drainage Board (hereinafter called the NWSDB).

1.2 Objective of the Study

The objective of the present study agreed upon is:

> to plan a technically-sound and economical long range water supply scheme for Amparai Group of Towns and ascertain the technical and financial feasibility of a project which is to be implemented.

The implementation of the scheme is proposed to be undertaken stage by stage considering the appropriateness of investment magnitude. The technical and financial feasibility of the stage I portion of the project will be studied.

The scope of work for the study agreed between the JICA and the NWSDB is presented in Appendix A.

1.3 Study Area

The area covered by the study area: Amparai U.C., Sammanthurai T.C. and its peripheral areas, Kalmunai T.C. and its surrounding V.C., Akkaraipattu V.C. and coastal area between Saindamaruthu and Akkaripattu with total area 93.5 km^2 (36.5 mi^2).

Due to geographical feature of the service areas between inland and coastal land, proposed service areas will be divided into two areas: Amparai U.C. area and coastal area inclusive of Sammanthurai area.

2. DESCRIPTION OF STUDY AREA

2.1 Location

The study area is located in the Amparai District, Eastern Province, with an area of 3,050 km^2, which is at 220 km away from the City of Colombo, and lies between 81°-28' to 81°-52' E longitude and 7°-05' to 7°-30' N latitude, and consists of the following area*:

Amparai Urban Council	:	whole area
Sammanthurai Pattu		
Sammanthurai T.C.	:	whole area
Sammanthurai V.C.	:	part
Karavahu Pattu		
Kalmunai T.C.	:	whole area
Karavahu North V.C.	:	whole area
Karavahu West V.C.	:	whole area
Karavahu South V.C.	:	whole area
Nintavur Pattu		
Karativu V.C.	:	part
Nintavur V.C.	:	part
Akkaraipattu North V.C.	:	part
Akkaraipattu Central V.C.	:	part

Amparai U.C. area is located on a plateau in western side of the district and others along the coast.

2.2 Topography

The study area is extended in a plateau of 30 to 60 m in elevation from sea level inclined toward the coastal land from the Senayake Samudra Reservoir, which is surrounded with mountains of elevation of 300 to 450 m, and a coastal land of 3 to 9 m elevation. The Gal Oya

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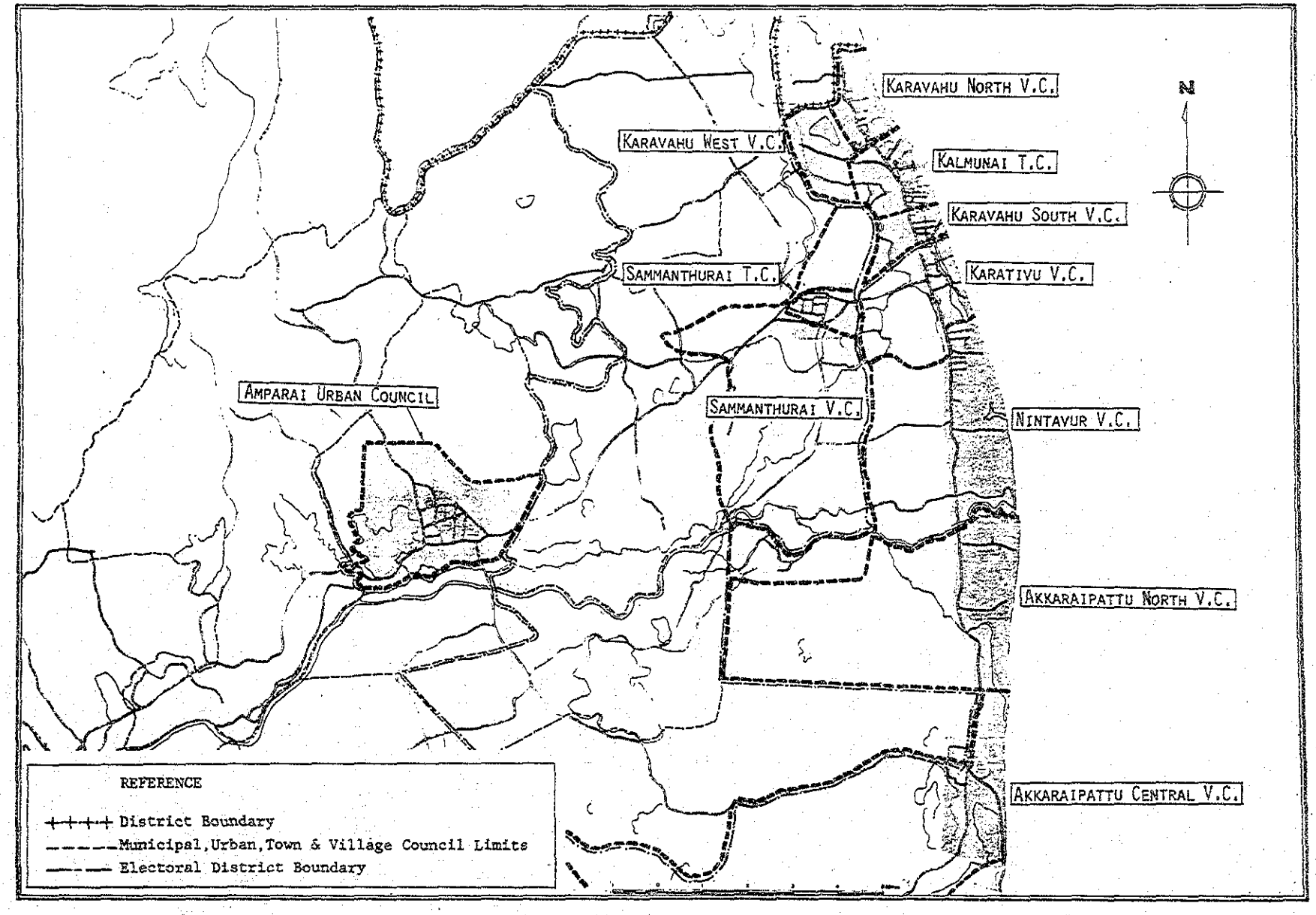
* Names of T.C. and V.C. depend on the former adminstrative name.

Fig. 2.1 Name of the Counciles and their Location



River flows to the Indian Ocean through the plateau dividing it into northern and southern parts. Due to dry weather especially in Sri Lanka, so many tanks impounding irrigation water are scattered in these plateaus.

By the implementation of the Gal Oya Development Program in 1950's, each tank was systematically connected with the Right Bank and Left Bank channels from the Senanayake Samudra Reservoir, which has a capacity of 940 million cu m (770,000 Ac.ft). The supplying of irrigation water has expedited the development of huge areas of cultivation for paddy and sugar cane fields from the plateau through coastal land.

2.3 Climatic Feature

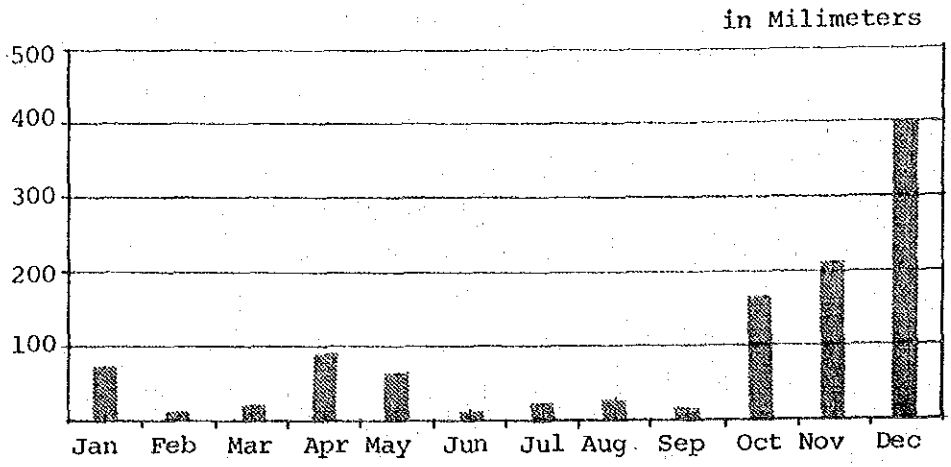
There are twice rainy seasons in a year in the Ceylon Island, namely, north-eastern monsoon season in October through February next and south-western monsoon season in May through September. The mountainous area lies with approximately 1,800 to 2,000 meters high above sea level between the City of Colombo and Amparai area, and the south-western monsoon interrupted by the mountainous area, causes much rain on the south-western area. Contrarily, due to the topographical feature, the Amparai area is dry during this period and average rainfall is less than 250 mm (10"). The north-eastern monsoon however brings more rain to the eastern area and average rainfall is about 1,000 to 1,250 mm (40" to 50"). The annual rainfall for past ten years and monthly rainfall in 1980 are shown in Tables 2.1 and 2.2, respectively.

Table 2.1 Annual Rainfall in Amparai Area

In Milimeter

Year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Rain-fall	-	1,365 (54")	1,342 (53")	1,530 (60")	1,610 (63")	1,469 (58")	1,315 (52")	1,284 (51")	1,304 (51")	1,119 (44")

Table 2.2 Monthly Rainfall in Amparai Area (1980)



The temperature in the area situated in the tropical zone shows max. 36°C (97.2°F), and min. 20°C (68.1°F) according to the meteorological data in 1971. The average temperature for every month in 1980 is shown in Table 2.2.

Table 2.3 Average Temperature in Amparai Area in 1980

In Degrees Centrigrade

Year / Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp.	26.2	26.3	27.6	28.8	30.1	31.0	30.6	29.7	29.0	27.9	26.7	26.1

3. SOCIOECONOMIC ASPECTS

3.1 Background

Amparai District is located in the eastern province of Sri Lanka, with a total area of 3,050 km^2, adjoining Batticaloa and Polonnaruwa Districts on the north; Matale and Badulla on the west; Monaragala and Hambantota Districts on the south. The District has developed along the Gal Oya Scheme, Nation's first irrigation scheme after independence, and known at present as a rice-producing district. Administratively, the District includes urban area of Amparai, newly developed town at the time of aforementioned scheme, and towns of Kalmunai, Sammanthurai, Saindamarudu and Akkaraipattu along the coast.

According to the 1981 Census, population in Amparai District is 388,786, showing an increase of 116,181 in the past ten years since the last 1971 Census of 272,605, with annual growth rate of 3.6 per cent. The present District population is about 2.6 per cent of the Nation's total population. Present density is reported as 130 per km^2.

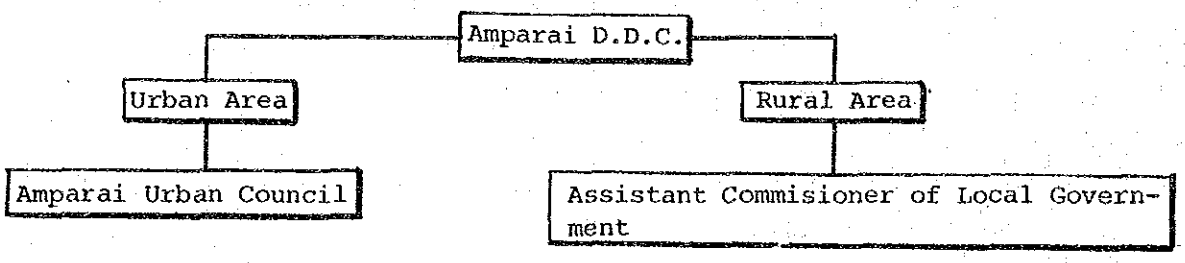
3.2 Study Area and Local Government Administration

From the present adminstrative control in the District area, the study area is to be divided into Amparai Urban Council area and coastal town area. While urban area of Amparai is within the administrative boundary of the Urban Council, towns of Kalmunai, Sammanthurai, Saindamarudu and Akkaraipattu located along the east coast, are within the administrative boundary of the District Development Countil.

It is to be noted that due to alteration of the law, the former Town Councils and Village Councils have been amalgamated under the administration of the District Development Council (D.D.C.), since 1980 by the resolution of the Government.

The administrative organization in Amparai District has also been reorganized to the present system since September 1980. Amparai Urban Council remains to be an independent council having the administrative control for the urban area, while the other Town Councils and Village Councils are under the administrative control of D.D.C. In each office of the former town and village councils, Assistant Commissioner of Local Government office is placed in order to give necessary administrative guidance.

The present administrative organization is illustrated below:



Kalmunai	District Council-Suboffice
Sammanthurai	- do -
Nintavur	- do -
Addalachenai	- do -
Akkaraipattu	- do -

The objectives and functions of the District Development Council will be summarized as:

a. General administration and staff services
b. Health services
c. Physical planning of thoroughfares, land and building
d. Public utility services
e. Water supply services
f. Welfare services
g. Electricity

According to the program budget 1982 of the District Council, the Council proposed a budget of Rs 15,365,000.

Being independent from the District Council, the Amparai Urban Council is administering the urban area of the District, with the powers and duties derived from the Urban Council Ordinance, and other Ordinances and Rules relating to the Local Government.

The main functions of the Urban Council are as follows:

a. Safeguarding and developing the public health activities and environmental health services necessary for the public welfare
b. Construction and maintenance of roads, including cleanliness and safeguarding
c. Carrying on and developing the welfare, social and other public services essential to the public
d. Controlling activities causing public hazards
e. Granting aid to those who are adversely affected by floods, fire, cyclones and volcanic eruptions.

According to the budget of Amparai Urban Council 1982, the Council is proposing a budget of Rs 2,354,930.

The more detail description of the Amparai Urban area and the coastal town area will be given below:

(1) Amparai Urban Area

Amparai Urban Town is the capital of the Amparai District and branch offices of most of the Government agencies are located in the town.

The urban area of Amparai was formed some 30 years back when Gal Oya scheme was started in 1950's. Before the scheme, the area was jungle. Since then, the town has been developed along the Gal Oya Scheme, providing residential space for employees and labourers engaged in the scheme, who migrated to the area from other part of the country.

Later, Amparai town has been developed independently from the Gal Oya Scheme being a rice distribution centre of this granary area linking with the village development program along the "Village Re-awakening Movement". Under the policy of the central government, migration to the area and its surrounding was encouraged to develop the land for paddy cultivation by providing free land to those who settled in the area, so called "Colonization Scheme".

In 1970's, business activities have also been introduced to the area, in addition to agricultural development. The government Co-operative Establishment has been set up, supplying textiles and provisions to shops in the town. Establishment of finance institutions also accelerated the business activities, though small in scale.

As to the industry, so far no large scale industry has existed except small scale brick making and weaving factories in the towns, nor will exist in the near future according to the town plan.

(2) Coastal Town Area

Towns of Kalmunai, Sammanthurai, Saindamarudu and Akkaraipattu are all located at the coastal area along the national route A4. The agriculture paticularly cultivation of paddy is predominant in all the towns besides fishery as secondary small scale activities.

The area is characterised ethnically to be the region of islamic and tamil society consisting of Tamil and muslim, forming own different society. This is called "pocket area", and it is reported that the society of the area will never intermingle each other. This must be carefully taken into consideration in assuming future projection of population and water demand.

3.3 Economy of the Study Area

Economy of the Amparai District is assumed to predominantly rely on agriculture. As previously stated, approximately 80 percent of the total population is estimated to be engaged in agriculture, 10 percent in business, 5 percent in fishery and 5 percent in various type of occupations. Only handful number of people earn their living from business and office work.

Average daily wages in agriculture and building construction are reported as follows:

	1979 (Rs)	1980 (Rs)
Paddy forming	19.10	25.77
Coconut planting	17.98	22.55
Tea planting	13.20	18.27
Rubber planting	14.50	20.51
Master Carpenter	27.51	36.80
Master Mason	27.08	35.70

Source: Statistic Dept. Central Bank of Ceylon.

It can be said that economic aspects in the District are still in the stage of its early development due to insufficiency of infrastructral facilities such as port, road networks and transportation system. Industries are limited to those small scale ones relating to agriculture and fishery in addition to a few cottage industries such as weaving mill and brick manufacturing.

3.4 Population

Population of Amparai District by urban and rural sectors is summarized below:

Total	Urban	per cent	Rural	per cent	Estate	per cent
388,786	53,603	13.8	335,183	86.2	-	-

According to the census of 1981, distribution of population by religion and ethnic group in the Amparai District was reported as follows:

Total population			388,786
Classified by:			
Religion	:	Buddhist	37.2%
		Hindu	19.1%
		Muslim	41.6%
		Christian	2.0%
		Other	0.1%
Ethnic	:	Sinhala	37.7%
		Sri Lanka Tamil	20.1%
		Indian Tamil	0.4%
		Moor	41.4%
		Burgher	0.2%
		Malay	0.1%
		Other	0.1%

Source: Statistic Department
Central Bank of Ceylon

Inhabitants of Moor are worshippers of Muslim and also the largest number of population in this District. Birth rate in this District is said as high as 3.8% exceeding national population increase rate of 1.7%. Akkaraipattu A.G.A. office claimed 4.4% of growth rate, The movement of family planning is enforced actively by the representative Town and Village Councils.

3.5 Infrastructures

(1) Amparai Urban Town

There are four principal roads available at present, maintained by the Highway Department, to access to the town; from the coastal route through Sammanthurai; another coastal route through Akkaraipattu; from northern route; and from southern route via Siyambalanduwa by passing main road through Inginiyagala. These roads, all paved with asphalt, are functioning as a basic infrstructure for development of the area.

Electricity is available for full day operation supplying to urban and limited number of rural area from Senanayake hydro-power station located at Inginiyagala which has a capacity of 10 M.W., supplemented sometime from Laksapana power station with the total capacity of 125 M.W. which is located 50 km to the south from Kandy.

The town presently has a water supply system which was originally designed in an ad hoc manner only to meet the temporary needs for the town during the construction stage of the Gal Oya Scheme. The present system was constructed in 1954 and now it is considered outdated. Detailes of the system will be given in Chapter 5.

Airport with a single runway of 800 m is located some 10 km to the north from Amparai town. Since there is no regular domestic flight at present, the airport is now used occasionally for a chartered flight only.

There are two district hospitals in the area. One is located in the town having approx. 200 beds, providing medical services for the community. Small clinics on private level also exist in the town, as well as a number of dispensaries. Other medical services are also being rendered under supervision of the Health Department.

Number of school students and teachers as well as other employees in this town are as follows:

	No. of Schools	No. of Students	Teachers	Other Employees
Primary School	3	2,567	—	—
Middle School	3	2,057	188	5
High School	3	814	—	—
Total	9	5,438	188	5

Source: Regional Education Department

(2) Coastal Towns

Electricity is available in all towns from the Senanayake hydro-power station mentioned earlier.

Main trunk road is linked to all the town. Some number of roads are also available within the town boundary.

There are many goldsmiths, jewellers, draperies, provisions and electric apparatus shops and eating houses along the trunk road. Business seems more active than Amparai Town.

The coastal towns were attacked by a terrible cyclone in 1978 and the towns appear under reconstruction stage from the serious damage. Therefore several private houses have newly been rebuilt of concrete.

Number of hospital and maternity houses accomodating approximately 400 beds in total are available at the coastal towns. Private clinics and dispensaries are also existing in the towns.

Numbers of schools, stduents and teachers as well as other employees the coastal area are reported as follows:

	School	Student	Teacher	Other Employees
Primary School	72	27,806	—	—
Middle School	11	11,093	1,387	33
High School	13	2,584	—	—
Total	96	41,483	1,387	33

Source: Regional Educational Department

3.6 Public Health and Incidence of Fire

3.6.1 Public Health

Although the figures are not available, the incidence of water related morbidity seems high and it has come to our notice that occurrence of the following water borne diseases was reported:

1) Non-specific diarrhea
2) Amoebic dysentery
3) Bacillary dysentery
4) Bacillary infectious hepatitis

Necessary preventive measures to control diseases have been taken by the Ministry of Health with special attention to:

1) preventive services
2) construction of latrines
3) health education programme

These activities have been in operation with strong assistance of UNICEF.

The World Bank Report on Sri Lanka issued on May 15, 1981 reported that 80% of the urban population in Sri Lanka has flush toilets, water seal, bucket or pit latrines, but only 8 % of the rural houses has the same facilities. Figures of 19% of the Urban and 92% of the rural houses have no disposal facilities.

Regional Health Department is extending their assistance to install sanitary latrine at the price of Rs 100 per set. However no charge is levied on the poor families.

3.6.2 Incidence of Fires

It is reported that there has been no incidence of fire in the District in the past few years nor record of fire occurrence is available in the District Development Council. It is also found that there has not been provided facilities of fire station nor engines in the District.

4. DEMOGRAPHIC ASPECTS

4.1 Past and Present Population

Actual census data of the whole country, Amparai D.D.C. area and the study area are available for 1963, 1971 and 1981 and are presented as below:

4.1.1 National Vital Statistics

Table 4.1 gives the population of Sri Lanka at each census and the inter-censal numerical increase of population and the percentage increase.

Table 4.1 Population, Numerical Increase and Percentage Increase

Year	Population	Numerical increase over Previous census	Percent increase	Average annual rate of growth (%)
1871	2,400,380	-	-	-
1881	2,759,738	359,358	15.0	1.4
1891	3,007,789	248,051	9.0	0.9
1901	3,565,954	558,165	18.6	1.7
1911	4,106,350	540,396	15.2	1.4
1921	4,498,605	392,255	9.6	0.9
1931	5,306,871	808,266	18.0	1.7
1946	6,657,339	1,350,468	25.4	1.5
1953	8,097,895	1,440,556	21.6	2.8
1963	10,582,064	2,484,169	30.7	2.7
1971	12,711,143	2,129,079	20.1	2.2
1981	14,850,001	2,138,858	16.8	1.6

Steep increase of population growth rate after 1946 may have been caused

by remarkable drop of mortality according to an intensive campaign for eradicating malaria while the high birthrate has continued. The decrease of growth rate during the period 1963 to 1981 may have been caused by the decline of birthrate. The average annual rate of growth was 1.6 per cent in the census in 1981.

4.1.2 Amparai D.D.C. Area

While the average annual growth rate for the whole country was 2.2 percent and 1.6 percent in 1971 and 1981, respectively, it is shown that the actual growth rate in Amparai D.D.C. Area was 3.2 percent and 3.6 percent in the same census. Following table gives the population and average annual growth rate in Amparai D.D.C. area.

Table 4.2 Population and Average Annual Growth Rate in Amparai D.D.C.

Year	Population	Average Annual Growth Rate %
1963	211,732	-
1971	272,605	3.2
1981	388,786	3.6

A reason of high rate of average annual growth in this area will be due to the migration from the other districts. Especially, Amparai U.C. shows a remarkable population increase of 4 percent for annual growth rate during past ten years of which 2 percent accounts for natural growth and another 2 percent social growth by migration. The migration has been caused because Amparai has become an administrative center in D.D.C. area.

4.1.3 Study Area

The population growth for each council in the study area is shown in Table 4.3 on the basis of the census data 1971 and 1981.

Table 4.3 Population Growth in Each Council in Study Area

Area No.	Council Name	Population 1971	1981	Percent Increase	Average Annual Growth Rate (%)
1.	Amparai U.C.	N.A.	16,531	-	-
2.	Sammanthurai T.C.	12,790	14,260	11.5	1.1
3.	Sammanthurai V.C.	N.A.	14,384	-	4.0*
4.	Kalmunai T.C.	19,180	22,812	19.0	1.7
5.	Karavahu North V.C.	-	19,655	-	-
6.	Karavahu West V.C	-	6,346	-	-
7.	Karavahu South V.C.	35,716	16,978	20.3	1.9
8.	Karativu V.C.				
9.	Nintavur V.C.	24,716	28,805	16.5	1.5
10.	Akkaraipathu North V.C.	N.A.	23,065	-	-
11.	Akkaraipattu Central V.C.	27,867	37,189	33.5	2.9
	Total (excluding 1,3 & 10)	120,269	146,045	21.4	1.9

Note: N.A.: Not Available
* : available from Assistant Government Agency (AGA) Division Office

The census data shows the average annual growth rate of 1.9 percent in whole council areas.

4.2 Population Projection

The Department of Census and Statistics prepared three series of population growth rate for projection of future population in the year 2001 starting in 1971, namely, high series of 2.2 percent, medium series of 1.8 percent and low series of 1.4 percent. As shown in Table 4.3, the growth rate in the study area is 1.9 percent per annum averaged for whole

areas and this is nearly equivalent to the medium rate series in the country. This 1.9 percent of annual rate may be considered adoptable for the projection of future population.

Accordingly, the future population in the study area was estimated applying 1.9 percent to average annual growth rate. For each former administration area, namely, U.C., T.C. and V.C. areas, the average annual growth rate in the past ten years was adopted for the projection, except 2.0 percent for Sammanthurai and Akkaraipattu areas, respectively.

Karavahu South V.C. is the most congested area in the Amparai D.D.C. and there seems to be no space to accept future population increase, and this population increase will migrate to Karativu D.C. and Nintavur V.C. areas. Then, it was assumed that the future population in Karavahu South V.C. is same as the present population.

Based upon the above conditions, the estimated average annual growth rate becomes 1.9 percent as a whole for study area. The future population projection estimated is shown in Table 4.4, as below:

Table 4.4 Population Projection for Study Area

	Area	Population						Study Area (ha)	Net Resident Density (Persons/ha)	Annual Growth Rate Adopted (Percent)
		1981**	1985	1990	1995	2000	2005			
1.	Amparai U.C.	16,531	19,300	23,500	28,600	34,800	42,400	2,410	10	4.0
	Sub-total	16,531	19,300	23,500	28,600	34,800	42,400	2,410	10	4.0
2.	Sammanthurai T.C.	14,260	14,900	15,700	16,600	17,600	18,500	270	65	1.1
3.	Sammanthurai V.C.	4,800*	5,200	5,700	6,300	7,000	7,700	230	27	2.0
4.	Kalmunai T.C.	22,812	24,400	26,500	28,900	31,400	34,200	720	54	1.7
5.	Karavahu North V.C.	19,655	21,200	23,300	25,600	28,100	30,900	610	49	1.9
6.	Karavahu West V.C.	6,346	6,800	7,500	8,300	9,100	10,000	550	58	1.9
7.	Karavahu South V.C.	16,978	17,000	17,000	17,000	17,000	17,000	420	121	0
8.	Karativu V.C.	28,805	30,600	32,900	35,500	38,200	41,200	1,690	27	1.5
9.	Ninatavur V.C.									
10.	Akkaraipattu North V.C.	21,300*	23,100	25,500	28,100	31,000	34,300	1,250	21	2.0
11.	Akkaraipattu Central V.C.	32,000*	34,600	38,200	42,200	46,600	51,500	1,200	44	2.0
	Sub-total	166,956	177,800	192,300	208,500	226,000	245,300	6,940	39	1.6
	Total	183,487	197,100	215,800	237,100	260,800	287,800	9,350	31	1.9

* based on hearing from AGA Division

** population in residential area

5. EXISTING WATER SUPPLY SCHEME

5.1 General

The NWSDB has eight regional offices in the country, and the regional office in Batticaloa operates ten water supply schemes inclusive of the existing schemes in Amparai D.D.C. in the Eastern Province.

Table 5.1 shows an outline of the existing water supply schemes in the project area. Amparai water supply scheme and Kalmunai water supply scheme are under control of the Regional Office for operation and maintenance and billing of water rate, and Sammanthurai water supply scheme is under construction under the supervision of the Regional Manager. Naipuddimunai-Chennaikudi water supply scheme, which was constructed in 1968 under the River Valley Development Board (RVDB), is operated by Karavahu V.C.

5.2 Historical Development

Amparai Water Supply Scheme

The Amparai U.C. area is a town established for persons engaged in the Gal Oya Development Programme in 1950's and developed by colonization thereafter. The water supply system of the town was started to construct the initial facilities in 1954 and completed the whole facilities with a capacity of 6,500 m^3/d (1.44 mgd) in 1958. Raw water is taken from the Amparai tank, and after coagulation and sedimentation, treated water is distributed to the town area through elevated towers by gravity. Pressure type filters were used for first ten years; however, at present they have been abandoned because of lack of technique for their operation and maintenance.

Summanthurai Water Supply Scheme

Sammanthurai Water Supply Scheme has been under construction since 1981. The water source is planned for Kallarachel Anicut* river, and

*Anicut: Head work of intake for irrigation water

Table 5-1 Existing Water Supply Scheme in the Project Area

Items	Amparai W.S.S.	Kalmunai W.S.S.	Naipuddimunai W.S.S.	Sammanthurai W.S.S. (under construction)
1. Existing Water Scheme				
Water Production (Design capacity)	6,500 m^3/d (1.44 mgd)	550 m^3/d (0.12 mgd)	90 m^3/d (0.12 mgd)	2,200 m^3/d (0.5 mgd)
Population served	15,000	10,000	2,000	-
Number of house connection and standpost	2,000 house connections 150 standposts	No house connection 21 standposts	No house connection 11 standposts	No house connection 26 standposts
Number of water meters	13mm 250 installed 13mm 100 reading	-	-	-
Raw water pumps	2 No x 200mm x 150mm x 75 HP	4 x 0.9 kW x 75mm	2 Nos: 1 electric and 1 diesel, diameter 100mm	-
Raw water transmission main	300mm (12") L = 1.9km (1.2 mi)	75mm (3") L = 70m (0.99 mi)	100m (4") L = 1.6 km (1 mi)	-
Sedimentation basin	4 basins 25.8m x 25.8m x 3m	-	-	-
Filter	-	2 x 74.4 m^2 (800 ft^2) slow filters, filtration rate 4.7 m/d (4 gal/ft^2/hr)	-	-
Transmission pumps	2 Nos x Ø200mm(8") Ø150mm x 75 HP	11 kW x 2 Nos	-	-
Transmission main	150mm(6") x 90m(300 ft) 2 lines	150mm (6") 720m (0.45 mi)	-	-
Clean water reservoir	V = 570 m^3 (125,000 gal) V = 230 m^3 (50,000 gal) V = 160 m^3 (35,000 gal) x 2 4.1 hrs retention time	V = 140 m^3 (30,000 gal) 6 hrs retention time	V = 90 m^3 (20,000 gal) 24 hrs retention time	V = 680 m^3 (150,000 gal) 7.4 hrs retention time
Distribution mains	Total / CIP / PVC / GSP 300mm(12") 1410m / 1410m / - / - 200mm(8") 1580 / 1580 / - / - 150mm(6") 8821 / 8821 / - / - 100mm(4") 11292 / 10234 / 467m / 591m 75mm(3") 3737 / 3349 / 319 / 69	100mm(4") CI 1230m(0.94 mi) 75mm(3") PVC 3770m(2.34 mi)	50mm - 38mm (2"-1 1/2") L = 2100m (1.3 mi)	200mm(8") PVC 230m(0.14 mi) 150mm(6") " 3590m(2.23 mi) 100mm(4") " 870m(0.54 mi) 75mm(3") " 5340m(0.24 mi)
2. Existing Water Sources				
For Tank				
Capacity	8,800,000 m^3 (7,140 Ac.ft)	-	-	-
Catchment area	17 km^2 (6.6 mi^2)	-	-	-
Water surface area	3.6 km^2 (896 acre)	-	-	-
Water level: H.W.L., L.W.L.	HWL + 26.67m (87.5 ft M.S.L.) LWL + 22.68m (74.4 ft M.S.L.)	-	-	-
Inflow rate	0.4 (m^3/sec) (14.5 cusec)	-	-	-
For Shallow Well				
Diamension	-	Ø3.6m (12 ft) d = 6m (20 ft) 2 Nos	Ø6m (20 ft) d = 5.4m (18 ft) 2 Nos	-
Yield	-	45 m^3/d (9,900 gpd)	90 m^3/d (20,000 gpd)	-
Raw water pumps	-	4 x 0.9 kW x 75mm	2 x 100mm	-
Supply hours	-	3 hrs per day	2 hrs per day	-

the construction of intake and filtration facilities is suspended, at present, due to lack of budget.

As for the alternative source, the investigation of groundwater has been carried out by NWSDB by means of geo-electrical survey and test well drilling at the site of 1.3 km south-west from the Anicut. Approximately 46 m^3/hr (10,000 gph, 1,000 m^3/d) of yield will be expected.

Kalmunai Water Supply Scheme

The scheme was established in 1980 consisting of two shallow wells, aeration and filtration facilities and distribution pipe lines with 21 standposts.

Water source is groundwater from shallow aquifer. One well is abandoned due to intrusion of saline water out of three wells and two wells are in operation at present. Due to poor yields, the wells are alternately operated resulting in intermittent water supply of one hour for every morning, noon and evening a day.

Naipuddimunai-Chennaikudi Water Supply Scheme

The Scheme was constructed under the River Valleys Development Board in 1968 before establishment of the NWSDB for supply of water to Karavahu West V.C. area. Water source is groundwater from shallow aquifer in the Kalmunai T.C. area. At present the operation of the scheme is performed by the Kalmunai AGA division, local government.

5.3 Source of Supply

5.3.1 Senanayake Samudra Reservoir

The Shnayake Samudra reservoir is located at the upstream of the Amparai tank, which is a water source of the Amparai Water Supply Scheme. The dam was constructed in Inginiyagala area as a multipurpose dam reservoir for irrigation, water supply and electric generation uses under the Gal Oya Development Program granted by U.S.A. assistance in 1952.

Its scale is as follows:

Catchment area	:	995 km^2 (384 mi^2)
Total capacity	:	950 million m^3 (770,000 Ac.ft)
Water surface area	:	77.9 km^2 (19250 acres)
H.W.L.	:	+79.20 m (+260 ft)
M.W.L.	:	+45.70 m (+150 ft)
Effective depth	:	33.50 m (110 ft)
Electric power	:	2.75 MW x 2 units 3.15 MW x 2 units Total 11.8 MW
Channels	:	Right Bank Max. design flow rate 13 m^3/sec. (450 cusec)
	:	Left Bank Max. design flow rate 42 m^3/sec. (1,500 cusec)

Water after electric generation is discharged to the Right Bank and Left Bank Channels and irrigates paddy and sugar cane fields spread in north and south sides of the Gal Oya River through tanks scattered in the area. Discharge from the reservoir is directed by the Irrigation Department, which decides quantity to be discharged according to the storage in and incoming flow into the reservoir. Minimum flow rate will be guaranteed at 0.7 m^3/sec (25 cusec) for drinking use. At non-irrigation period in dry season, past record shows that only 6 m^3/sec (200 cusec) was discharged to the Right Bank Main Channel after electric generation of one MW with 18.9 m (62.09 ft) of the effective water depth in the Reservoir.

5.3.2 Amparai Tank

The Amparai Tank was constructed for irrigation water use in 1900's and shifted to an exclusive use for the water supply scheme after completion of the Gal Oya Development Program in 1952. The scale of the tank is as follows:

Catchment area	:	17 km^2 (6.6 mi^2)
Total capacity	:	8.8 million m^3 (7,140 ac.ft)
Water surface area	:	3.6 km^2 (896 acres)
Effective depth	:	4.0 m (13.1 ft)
H.W.L.	:	+26.68 m (87.50 ft)
L.W.L.	:	+22.68 m (74.40 ft)

Raw water discharged to the Left Bank Main Channel flows to the tanks scattered in the northern irrigation areas through the Aligalge and Himidurawa tanks and a part of the raw water flows into the Kondavattavan and Amparai tanks from the Himidurawa tank.

Surrounding area of northern and western parts of the Amparai tank is covered by jungle, where wild elephants haunt. The Amparai D.D.C. has been making efforts for the environmental preservation of the tank prohibiting construction of buildings and pasturing of livestocks around the tank so that the water is free from external contamination.

In the tank, Salvinia, a kind of water plant, have propagated itself and are drifting here and there on the surface of reservoir blown by the wind. The floating Salvinia are harmless for the intake facilities; however, dead one settled in the tank causes interruption of operation of raw water pumps and comes out from taps without being caught through water treatment process.

5.3.3 Shallow Wells

The Kalmunai Water Supply Scheme has two shallow wells as water source which are located with 36 meters interval in the treatment plant, constructed in 1980. While three wells were dug at the initial stage for proposed production 545 m^3/day (120,000 gpd), due to intrusion of saline water, one well dug in the lagoon area was abandoned. At present two wells are in operation. In fact, however, water production is merely 46 m^3/day (10,000 gpd) so that water supply is limited for 3 hours a day. Dimensions of the wells are as follows:

Diameter : 3.6 m (12 ft)
Total depth: 6.0 m (20 ft)
Water depth: 1.5 m (5 ft)

There are some small schemes relying upon the shallow wells constructed under UNICEF program in the project areas.

5.3.4 Water Quality

NWSDB has only one laboratory in the headquarter, Colombo throughout the country except own laboratory of the Colombo Water Supply Scheme. Generally, water quality analysis is conducted for raw water and finished water sampled from standpost/s within 24 hours at the laboratory, with frequency of once a month for large cities, once in every two or three months for medium cities and once in every six months for small towns. The items analyzed in the laboratory and their standard are as follows:

Physical items	Unit	Highest/Maximum desirable/permissible
Turbidity	(JTU)	2 / 10
pH	-	7.0 - 8.5 / 6.5 - 9.2
Electric conductivity	(μ℧ cm)	-
Colour	(Hazen scale)	5 / 50
Total dissolved solids	(mg/l)	500 / 1,500
Chemical items		
Total alkalinity	(mg/l)	-
Chloride ion	(")	200 / 600
Nitrate nitrogen	(")	45
Nitrite nitrogen	(")	-
Ammonia nitrogen	(")	0.5
Albuminoid ammonia	(")	-
Iron Total	(")	0.3 / 1.0
Manganese (as Mn)	(")	0.1 / 0.5

Chemical items	Unit	Highest/Maximum desirable/permissible
Sulfate ion	(mg/l)	200 / 400
Magnesium (as Mg)	(")	50 / 150
Fluorides (as F)	(")	1.5
Total hardness (as $CaCO_3$)	(")	100 / 500
Bacteriological items		
Coliform group	(MPN/100ml)	10 MPN

(1) Amparai Tank

The result of water quality analysis conducted by the Board in 1980 to 1981 are shown in Table 5.2. Table 5.3 gives the water quality of the present raw water and settled water for the Amparai tank during the course of field survey.

The water quality characterizes that coliform group which is an index of contamination by pathogenic germs is presented as negative and high pH value over 7.0 is detected even after coagulation, which usually lowers the value. It may be due to the presence of algae in the raw water. The raw water has musty smell of which removal will be made by the slow sand filtration, biological oxidation and activated carbon adsorption.

(2) Shallow Wells in Kalmunai

As shown in the Tables 5.4, high contents of total hardness and chloride ion caused by the intrusion of saline water are detected. Although high contents of iron is detected, this is removed by aeration and sand filtration to the extent of allowable value. In general the groundwater in the District area is considered being subjected to intrusion of saline water.

Table 5.2 Raw Water Quality of Amparai Tank

Items	1980								1981					
	Jan.	Feb.	May	June	July	Aug.	Oct.	Nov.	Jan.	Feb.	Mar.	Apr.	July	Nov.
Turbidity (JTU)	10	60	7.6	9.4	7.2	13.5	30	2.9	4.0	8.4	64	10	6.0	5.8
pH	7.2	7.2	7.0	6.8	6.8	7.2	7.2	6.5	6.8	7.6	6.2	7.6	7.0	6.7
Electric Conductivity	110	135	140	135	142	145	195	135	120	150	120	120	200	120
Chloride Ion	40	14	24	22	22	19	28	18	20	24	12	20	36	18
Alkalinity	40	48	52	32	56	53	65	52	39	58	40	54	56	54
Dissolved Solids	74	90	91	86	89	91	-	89	80	99	69	78	135	79
Nitrates	MT	MT	MT	MT	MT	MT	MT	MT	MT	MT	MT	MT	MT	MT
Nitrites	MT	MT	MT	MT	MT	MT	MT	MT	MT	MT	MT	MT	MT	MT
Free Ammonia	0.35	0.35	0.06	0.08	0.05	0.84	0.12	0.42	0.04	0.25	0.08	-	0.15	-
Albuminoid Ammonia	1.05	0.55	0.18	0.15	0.18	0.76	0.36	0.64	0.15	0.50	0.15	-	0.20	0.40
Iron	0.08	2.4	0.50	0.48	0.70	1.0	0.24	0.32	0.20	0.46	0.40	0.30	0.70	0.40
Colour	15	45	10	15	15	75	28	8	10	25	30	5	10	20

MT: Minute Trace

Source: NWSDB

Table 5.3 Water Quality of Amparai W.S.S.

Item		Raw Water			Settled Water		Stand-post	Stand-post
Distance from Plant		-			-		800 m	2,300 m
Sampling Date		3 Mar 1982	10 Mar 1982	24 Mar 1982	3 Mar 1982	24 Mar 1982	3 Mar 1982	3 Mar 1982
Water Temperature	°C	30.5	30.5	28.0	30.5	28.0	29.5	30.6
pH		7.4	7.0	7.4	7.4	6.8	7.2	7.2
Turbidity	degree	150	85	100	45	75	45	42
Color	"	20	30	30	15	30	15	15
Alkalinity	mg/l	34	35	36	34	30	28	26
Potassium Permanganate Consumed	"	79.0	53.1	-	44.2	-	41.1	47.4
Nitrate Nitrogen	"	ND	-	-	ND	-	ND	ND
Ammonia Nitrogen	"	0.27	0.33	0.50	0.23	0.50	-	-
Hardness	"	27	-	28	37	-	34	34
Chloride Ion	"	20	-	20	22	-	21	22
Phenols	"	ND	-	-	-	-	-	-
Iron	"	0.20	0.40 (0.15)	0.50 (0.15)	0.05	0.25 (0.15)	0.05	0.05
Manganese	"	0.02	0.04	0.06	0.02	0.09	0.02	0.02
Chromium	"	ND	-	-	-	-	-	-
Copper	"	ND	-	-	-	-	-	-
Coliform Group	Nos/ml	0	0	-	0	-	0	0
Total Colonies	"	229	720	-	72	-	6	6
Residual Chlorine	mg/l	-	-	-	0.2	-	0.1	0

Note: ND : not detected

( ): for dissoloved iron

Table 5.4 Water Quality of Kalmunai W.S.S.

Item		Raw Water	Finished Water	Standpost (1,600 m)
Date		8 Mar 1982	8 Mar 1982	8 Mar 1982
pH		7.8	8.0	8.0
Turbidity	degree	< 10	< 10	< 10
Colour	"	3	2	2
Alkalinity	mg/l	90	70	72
Ammonia Nitrogen	"	0.67	0.05	0.05
Hardness	"	350	-	-
Chloride Ion	"	290	-	-
Iron	"	1.30	0.10	0.15
Manganese	"	0.15	0.09	0.04
Coliform Group	Nos/ml	0	0	0
Total Colonies	"	21	0	80
Residual Chlorine	mg/l	-	2.0	0.1

On the other hand, coliform group by external contamination is detected as negative.

5.4 Existing Water Supply Schemes

5.4.1 Amparai Water Supply Scheme

The raw water from the Amparai tank is transmitted to the treatment plant at the central area of the town through 300 mm (12") raw water main by raw water pump which is installed at the southern bank of the tank. The suction pipes of pumps are directly put into the tank, so that suction of dead Salvinia is unavoidable. To prevent the suction of dead Salvinia, NWSDB has planned to install an intake crib of cylinder type of 3.0 m in diameter around rising pipes of suction.

The treatment plant is located at a hilly place in the town. The treatment facilities are composed of four sedimentation basins of batch system and chemical dosing facilities for pre-chlorination and alum feeding which were constructed in 1954 and 1958. Four sedimentation basins are separated into two groups, each of one coagulation and one sedimentation basins, and other two sedimentation basins, and operated with six hours interval including two hours sedimentation process and desludging after pumping up the settled water to the elevated towers.

Pre-chlorination is applied at 3 mg/l for oxidising iron and manganese and minimum residual chlorine is kept at 0.1 mg/l at the end of distribution pipelines. At present chlorine gas is used for the chlorination taking advantage of local product available while initially breeching powder imported form India was used.

Six filters of pressure type were installed at the initial stage and operated for about ten years. However, due to problems of operation and maintenance, they were abandoned for twenty years, and only settled water has been supplied in the service area.

Four elevated towers are in the plant, two reinforced concrete

towers each 320 m^3 (70,000 gal) and two steel towers each 800 m^3 (175,000 gal). Treated water is supplied by gravity to the area.

Distribution pipelines consist of cast iron pipes, PVC and GSP pipes for 100 mm (4") and below, and total length is about 33 km from 50 mm (2") to 300 mm (12") in diameter.

5.4.2 Kalmunai Water Supply Scheme

The scheme started in 1980 for construction of the facilities for the design capacity of 550 m^3/d (120,000 gpd). At present, two shallow wells (3.6 m in diameter and 6 m deep) are obliged to be in alternate operation due to a poor yield for water supply, especially in dry season. Then, water supply is limited to 46 m^3 (10,000 gal) for three hours a day.

As raw water contains high concentration of iron, treatment facilities are equipped with aeration and filtration systems for removal of iron. Water through aeration is conveyed to slow sand filter and after filtration water is chlorinated by chlorine gas at the entrance of suction well for transmission pumps.

Pure water without iron after chlorination is stored in the elevated tower with a capacity of 140 m^3 (30,000 gal) and supplied to the consumers through 21 standposts installed in the service area.

5.4.3 Sammathurai Water Supply Scheme

As mentioned above, the scheme is now under construction, and due to lack of the project budget, the construction of intake facilities from the Kallarachel anicut river and treatment facilities is suspended at present.

On the other hand, the NWSDB has continued the groundwater investigation executing the geo-electric survey and test well drilling.

For the time being, the groundwater will be pumped up to the elevated tower constructed at south of Sammanthurai T.C. area, and distributed to the service area after chlorination.

The distribution systems are composed of an elevated tank with a capacity of 680 m^3 (150,000 gal) and distribution pipes of total length of 10 km ranging 75 mm to 200 mm (3" to 8") in diameter with 26 stand-posts.

5.4.4 Naipuddimunai - Chennaikudi Water Supply Scheme

The scheme was constructed in 1968 to supply for Karavahu West V.C. and consists of two shallow wells (6 m in diameter and 5.4 m deep), an elevated tower 90 m^3 (20,000 gal) and distribution pipelines. At present 90 m^3 (20,000 gal) is supplied for two hours intermittently.

5.5 Operation and Maintenance

Existing water supply schemes in Amparai and Kalmunai are operated under the control of Regional Manager for the fields of intake station, treatment plant meter reading and house connection works.

Amparai water supply scheme is operated and maintained by 40 staff headed by the Scheme Manager who are composed of 12 pump operators for intake pumps, high lift pumps in the plant and booster pumps, 8 watchers for office and stores of chemicals, water meters and materials of house connection, 8 tank attendants and 12 labourers including casuals.

Routine works of staff are:

1) operating of intake pumps and high lift pumps according to intermittent operation of four sedimentation basins,
2) dosing of alum and chlorine
3) dewatering of sludge and sweeping of sedimentation basins,
4) operating of booster pumps,

5) watching of tank,

6) repairing of house-connections,

7) controlling of materials for pipes, valves and house connection.

At present 250 water meters have been installed for part of total 2,000 house connections since last year, and out of them about 100 meters are being read for billing of water used. Therefore, meter reading once every month is also one of routine jobs in the scheme.

Kalmunai water supply scheme is operated and maintained by three staff. Surface scraping of the slow sand filter bed is made once a month and for 3 to 4 days by 3 labourers.

5.6 Evaluation of the Existing Schemes

The evaluation of the existing schemes are summarized as follows:

5.6.1 Amparai Water Supply Scheme

1) Water supply facilities were constructed in 1950's, so that the facilities are deteriorated as a whole.

2) Intake facilities should be remodelled so as to prevent intrusion of the dead Salvinia.

3) Efficiency of sedimentation is not good due to lack of coagulation process and improper dosage of chemicals.

4) Settled water which is of almost same quality as the raw water is supplied to the consumers.

5) In order to supply water of better quality to the consumers, an improvement of water treatment is needed.

6) Remodelling of the facilities shall be implemented as an immediate programme before completion of the new water supply scheme.

7) In future, the existing treatment plant will be replaced by the distribution centre, and the existing elevated towers will be utilized to distribute the water to limited area, viz, lower zone in the service area.

8) The existing distribution pipelines will be incorporated in the future scheme and old pipes be replaced by new pipes.

5.6.2 Kalmunai Water Supply Scheme

1) Groundwater is contaminated by saline water from lagoon close to the shallow wells.

2) The existing elevated tower will be used continuously in the future shceme.

3) The existing distribution pipelines will be incorporated into the future sheme.

4) The existing treatment plant will be abandoned after completion of the future scheme.

5.6.3 Sammanthurai Water Supply Scheme

1) Construction of intake and treatment facilities has been suspended due to lack of the project budget of the NWSDB.

2) Groundwater investigation was carried out, inclusive of test well drilling with an aim to acquire, within a shortest possible time, drinking water not requiring any treatment. However, the water sampled from test well with 65 mm (1 1/2") in diameter and 9 m (28 ft) deep contains 8.0 mg/l of iron, 0.21 mg/l of manganese and 2.67 mg/l of ammonium. To remove these contents, aeration and slow sand filtration processes are essential.

3) For the time being, groundwater will be supplied for Sammanthurai area without chlorination.

4) All the facilities installed in the Sammanthurai water supply scheme will be incorporated into the future scheme.

5.6.4 Naipuddimunai - Chennaikudi Water Supply Scheme

1) The elevated tower with a capacity of 90 m^3 (20,000 gal) will be incorporated into the future scheme.

2) Shallow wells will be abandoned after completion of the future scheme.

5.7 Remodelling of Amparai Treatment Facilities

As described in the previous section, the remodelling of the facilities will be recommended for overall improvement of the present water treatment, as outlined below:

1) Batch type sedimentation basin shall be altered to continuous type. By this measure, water production will be increased to 3,300 m^3/d (0.73 mgd) from the existing capacity of 2,600 m^3/d (0.57 mgd).

2) Flocculation process shall be added remodelling the existing sedimentation basin to make effective coagulation.

3) Supernatant water, after settling shall be taken.

4) Chemical solution tanks for alum and lime shall be provided. Besides, present dosing rate of chemicals shall be increased to appropriate dosage rate.

To realize the above, the following remodelling is recommended:

1) Two basins will be combined into one unit and be used for flocculation and sedimentation. In both basins, training walls shall be installed to eliminate short circuit flow and dead water (See Appendix D-19, 20).

2) Rapid mixing will be done utilizing the remaining head of raw water at the inlet of the basin. Around-the-end type baffle plates shall be installed in the flocculation basin.

3) Overflow walls shall be installed around the suction pipe of the transmission pump.

4) The following solution tanks shall be provided:

Alum solution tank : 3.5 m^3 (770 gal)
Slaked lime solution tank: 0.7 m^3 (160 gal)

Capacities of both tanks are equivalent to a volume of chemical dosage per day, respectively.
Dosing will be done by gravity flow.

5) The present chemical dosage shall be increased and post-lime dosage be applied for pH correction since alkalinity will reduce according to the increase of alum dosage.

Appropriate dosages are as follows:

Chemicals	Present (mg/l)	Recommended (mg/l)
Chlorine:	3.0	5.0
Alum :	22.0	75.0
Lime :	-	12.0

6. LONG RANGE WATER SUPPLY SCHEME UP TO THE YEAR 2005

6.1 General

This Chapter describes the whole plan up to the year 2005 for Amparai Group of Towns Water Supply Scheme. The plan has been developed based on projected population to the year 2005 and the area to be served has been zoned covering congested areas of inland and coastal land within the study area.

Future water requirements have been estimated as a total of domestic, commercial, institutional, hospital, school and industrial uses including leakage. The domestic use is obtained as a product of the served population and percapita consumption, calculated separately for house connection consumers and standpost users.

As for potential water sources to meet the future water requirement, Amparai tank and Kondavattavan tank for Amparai water supply scheme, and Kallarachel and Smabuveli anicuts river and Kaliodai anicut river for the Coastal area water supply scheme have been investigated on environmental status, capacity and flow rate and their water quality. On the basis of the results of water qulaity analysis and coagulation test, water treatment process has been studied inclusive of appropriate chemical dosage.

The service area is divided into two areas depending on geographical features, that is, Amparai area and Coastal area. For each service area, several alternatives of water sources for the scheme are considered, e.g.,such as Amparai tank or Kondavattavan tank for Amparai water supply scheme and one or two or three water sources from anicut river water for the coastal area water supply schemes in North Coastal area, Sammanthurai area and South Coastal area. Accordingly, the comparative study has been conducted for the above mentioned alternatives to plan the future water systems in the year 2005 based on the least cost solution.

6.2 Service Area

The areas to be served by the future water supply system in the target year 2005 are proposed as follows:

Amparai area:

Urban Council area except the Amparai tank and its surrounding area of upstream side of the tank.

Sammanthurai area:

Town Council area and neighbouring area of Northern part of Sammanthurai V.C. area.

Kalmunai Electlorate area:

Kalmunai T.C., Karavahu West, North and South areas excluding paddy field and lagoon areas.

Karativu and Nintavur areas:

Karativu V.C. and Nintavur V.C. areas excluding paddy field and lagoon areas.

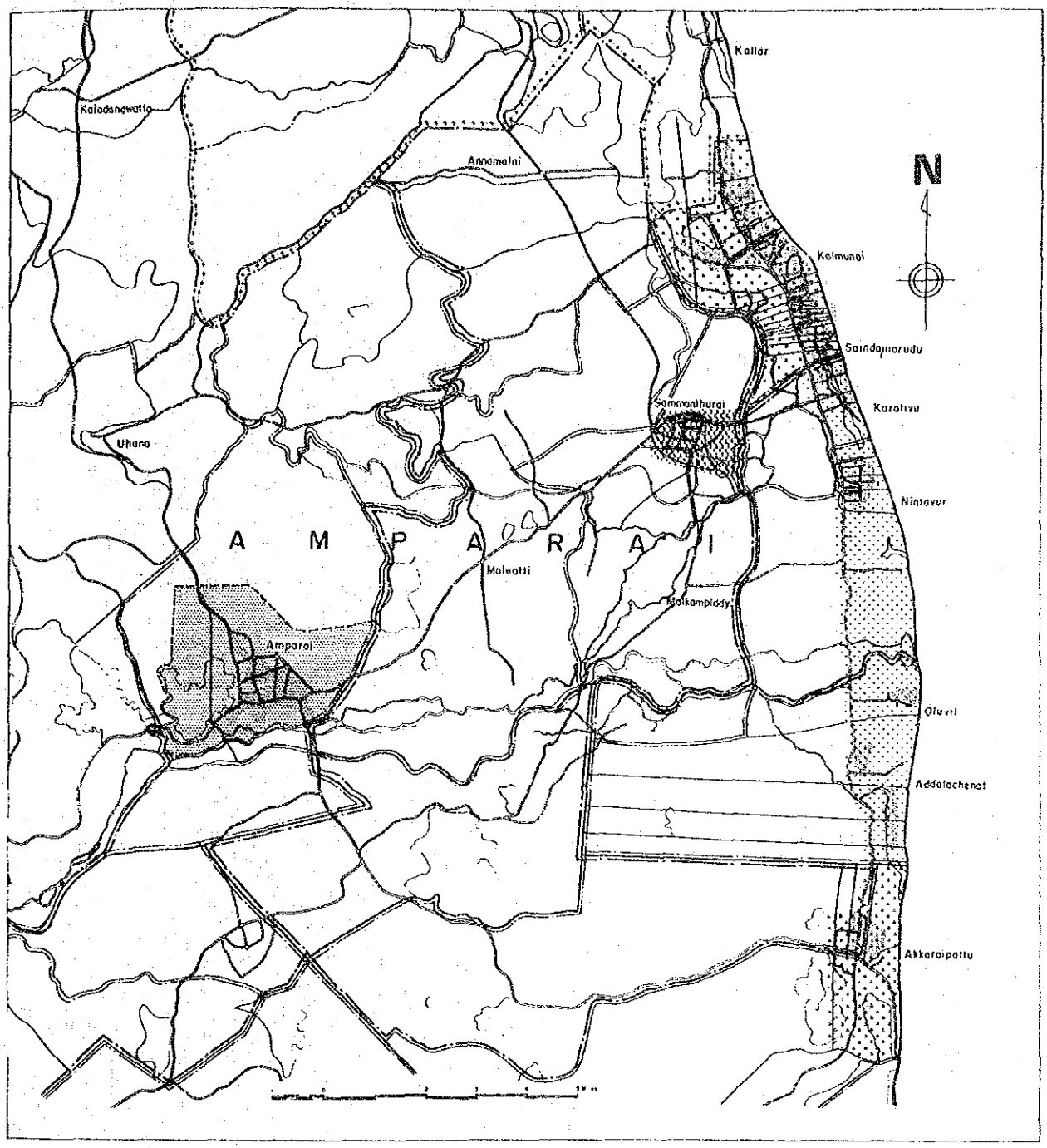
Addalachenai and Akkaraipattu areas:

Akkaraipattu North (Addarachenai) and Central areas excluding paddy field and lagoon areas.

Present congested town areas and proposed service areas in the target year 1995 and 2005 are shown in Figs. 6.1, 6.2 and 6.3 respectively. The service area is as follows:

	1995	2005
Amparai Area	527 ha	672 ha
Coastal Area	2,205	2,653
	2,732 ha	3,325 ha

Fig. 6.1 Present Congested Town Area



REFERENCE

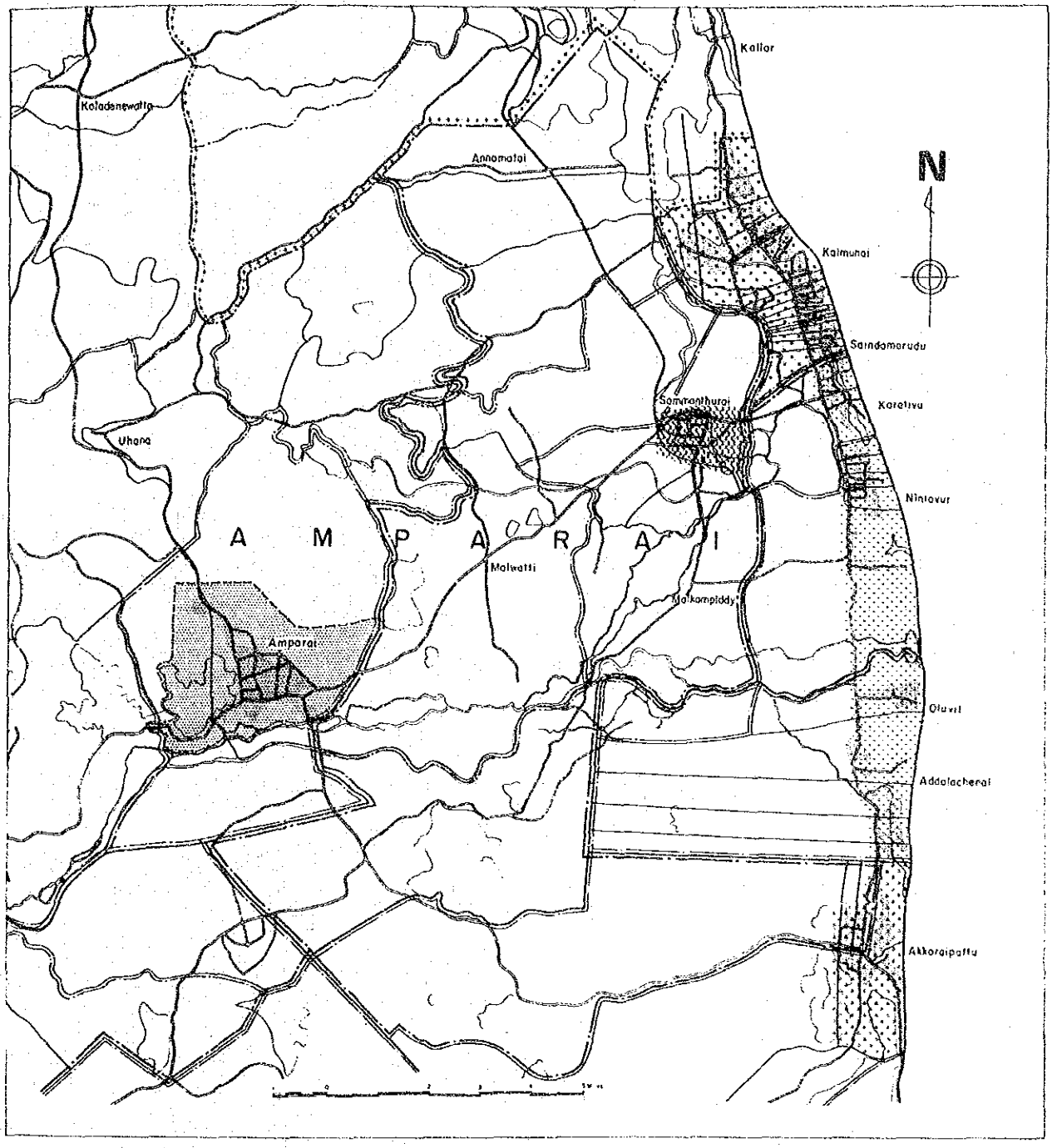
+ + + + +	District Boundary
———	D.R.O's Divison Boundary
———	Grama Sevaka Division Boundary
——·——	Municipal, Urban, Town & Village Council Limits
———	Electoral District Boundary
	Congested Area

Remark

Study Area

	KALMUNAI + SAINDAMARUDU
	AMPARAI U.C.
	AKKARAIPATTU T.C.
	SAMMANTHURAI T.C.
	Coastal arera-KARATIVU+NINTAVUR

Fig. 6.2 Service Area in the Target Year 1995



REFERENCE

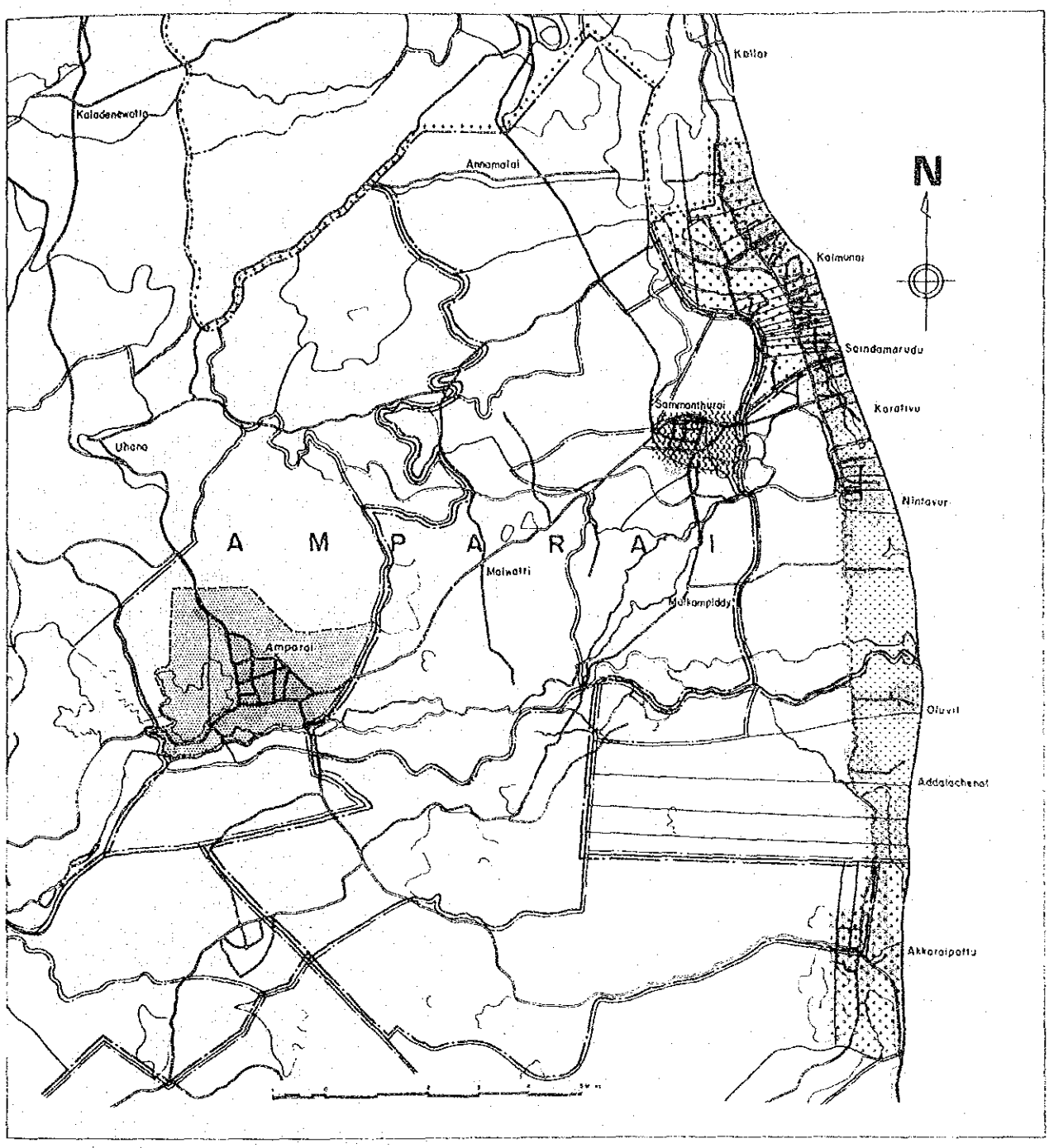
+ + + + +	District Boundary
———	D.R.O's Divison Boundary
———	Grama Sevaka Division Boundary
———	Municipal, Urban, Town & Village Council Limits
———	Electoral District Boundary
	Service Area

Remark

Study Area

	KALMUNAI + SAINDAMARUDU
	AMPARAI U.C.
	AKKARAIPATTU T.C.
	SAMMANTHURAI T.C.
	Coastal area-KARATIVU+NINTAVUR

Fig. 6.3 Service Area in the Target Year 2005



REFERENCE

+ + + + + District Boundary

D.R.O's Divison Boundary

Grama Sevaka Division Boundary

Municipal, Urban, Town & Village Council Limits

Electoral District Boundary

Service Area

Remark

Study Area

KALMUNAI + SAINDAMARUDU

AMPARAI U.C.

AKKARAIPATTU T.C.

SAMMANTHURAI T.C.

Coastal area-KARATIVU+NINTAVUR

6.3 Water Requirement

The water demands for the project area are developed on the basis of basic data on present consumption obtained by hearing for each group of domestic and non-domestic consumers during the field investigation and the future development plan, especially, in Amparai U.C. prepared by the Urban Development Authority.

6.3.1 Population Served

Future population is projected up to the year 2005 in the previous chapter, Demographic Aspects, and shown in Table 4.4. The present population served is assumed at 15,000 in Amparai U.C. area, and at 10,000 in Kalmunai area, and about 90 percent and 44 percent of service rate for total population, respectively.

To project the future population served, assumption is made that in the year 2005, the population served will reach up to 95 percent and 90 percent of the total population in the Amparai area and Coastal area, respectively. For the intervening years, the projected population served is interpolated using arithmetical progression rate determined for the period 1985 to 2005.

The present population served is classified into two categories, i.e., direct consumers served by house connections and indirect consumers by standposts. The percentage of the population served for direct consumers and indirect consumers are estimated as follows on the basis of field investigation:

	Amparai area		Coastal area	
	H (%)	S (%)	H (%)	S (%)
1981 - 1985	60	40	30	70
2005	70	30	60	40

H: Direct consumers by house connections
S: Indirect consumers by standposts

Population served in 1985, 1995 and 2005 is shown in Table 6.4.

Table 6.4 Population Served

		Served Population Rate			Population Served		
		1985	1995	2005	1985	1995	2005
		%	%	%			
Amparai U.C.		90	92	95	17,400	26,300	40,300
	H	60	65	70	10,400	17,100	28,200
	S	40	35	30	7,000	9,200	12,100
Sammanthurai T.C.		50	70	90	7,500	11,600	16,700
	H	30	45	60	2,250	5,200	4,100
	S	70	55	40	1 800	2,400	2,800
Sammanthurai V.C.		50	70	90	2,600	4,400	6,900
	H	30	45	60	800	2,000	4,100
	S	70	55	40	1,800	2,400	2,800
Kalmunai T.C.		50	70	90	12,200	20,200	30,800
	H	30	45	60	3,700	9,100	18,500
	S	70	55	40	8,500	11,100	12,300
Karavahu North V.C.		50	70	90	10,600	17,900	27,800
	H	30	45	60	3,200	8,000	16,700
	S	70	55	40	7,400	9,900	11,100
Karavahu West V.C.		50	70	90	3,400	5,800	9,000
	H	30	45	60	1,000	2,600	5,400
	S	70	55	40	2,400	3,200	3,600
Karavahu South V.C.		50	70	90	8,500	11,900	15,300
	H	30	45	60	2,550	5,400	9,200
	S	70	55	40	5,950	6,500	6,100
Karativu V.C.		50	70	90			
	H	30	45	60			
	S	70	55	40			
Nintavur V.C.		50	70	90	15,300	24,900	37,000
	H	30	45	60	4,600	11,200	22,200
	S	70	55	40	10,700	13,700	14,800
Akkaraipattu N. V.C.		50	70	90	11,500	19,700	30,900
	H	30	45	60	3,400	8,900	18,500
	S	70	55	40	8,100	10,800	12,400
Akkaraipattu C. V.C.		50	70	90	17,300	29,600	46,400
	H	30	45	60	5,200	13,300	27,900
	S	70	55	40	12,100	16,300	18,500
Total					106,300	172,300	261,100
H: House Connection				H	37,100	82,800	160,700
S: Standpost				S	69,200	89,500	100,400
				Amparai	17,400	26,300	40,300
				H	10,400	17,100	28,200
				S	7,000	9,200	12,100
				Coastal	88,900	146,000	220,800
				H	26,700	65,700	132,500
				S	62,200	80,300	88,300

6.3.2 Water Demand for Domestic Consumption

The present domestic consumption is investigated and obtained by the field consumption survey. The result indicates that out of the total domestic consumption, 91 lpcd is used by house connection users and 38 lpcs by standpost users. Due to supply of unsatisfactory quality and quantity under a low pressure, the domestic consumption of house connection users seems comparatively small. When the scheme is completed, however, plentiful pure water will be distributed to the whole service area and per capita consumption is anticipated to accordingly increase.

Considering all the above, a figure 40 gpcd is adopted for long range future per capita demand of house connection users, as has been applied by the NWSDB for other water supply schemes. Increase of per capita demand up to 2005, therefore, is planned as shown below.

Unit demand for house connection user

135 lpcd (30 gpcd) in 1986
160 lpcd (35 gpcd) in 1995
180 lpcd (40 gpcd) in 2005
Annual increase: 1.2%

Unit demand for standpost user

40 lpcd (9 gpcd) all through the year up to 2005

Domestic demand as above calculated is presented in Table 6.5.

6.3.3 Water Demand for Non-domestic Consumption

Water demand for non-domestic consumption includes uses for public and private institutions, educational institutions, hospitals, and industries, etc. The projection of demands is summarized in the following paragraphs.

1) Water demand of Educational Institutions

The number of pupils of primary and secondary schools is obtained from the Education Board of Amparai District. According to the information, the present composite percentages of pupils of primary and secondary schools in the study area show 25.4 percent of the total population.

Table 6.5 Water Demand for Domestic Consumption

(Unit : m^3/d)

		1985	1995	2005
Amparai U.C.		1,757	3,104	5,560
	H	1,477	2,736	5,076
	S	280	368	484
Sammanthurai T.C.		530	1,088	2,068
	H	320	832	1,800
	S	210	256	268
Sammanthurai V.C.		186	416	850
	H	114	320	738
	S	72	96	112
Kalmunai T.C.		865	1,900	3,822
	H	525	1,456	3,330
	S	340	444	492
Karavahu North V.C.		750	1,676	3,450
	H	454	1,280	3,066
	S	296	396	444
Karavahu West V.C.		238	544	1,116
	H	142	416	972
	S	96	128	144
Karavahu South V.C.		600	1,124	1,900
	H	362	864	1,656
	S	238	260	244
Karativu V.C.		1,081	2 340	4,588
	H	653	1,792	3,996
Nintavur V.C.	S	428	548	592
Akkaraipattu North V.C.		807	1,856	3,826
	H	483	1,424	3,330
	S	324	432	496
Akkarapattu Central V.C.		1,222	2,780	5,762
	H	738	2,128	5,022
	S	484	652	740
Total		8,036	16,828	32,942
	H	5,268	13,248	28,926
	S	2,768	3,580	4,016
Amparai		1,757	3,184	5,560
	H	1,477	2,736	5,076
	S	280	368	484
Coastal		6 279	13,724	27,382
	H	3,791	10,512	23,850
	S	2,488	3,212	3,532

The future enrollment rate to total population is assumed as equal to the present rate.

The field survey reveals that the unit consumption per pupil is about 4 l/pupil, and for consumption in 1985, this value is adopted.

For future consumption, it is assumed that in 1995 unit consumption is 10 l/pupil and in 2005, 20 l/pupil.

The result is shown in Table 6.6.

2) Water Demand of Hospitals

The demand of hospitals will be estimated considering the number of available beds. The number of beds is assumed to increase at the same rate as population growth. For Amparai U.C., 4.0 per cent, and for the others, the composite 2.1 per cent annual growth rate is assumed.

Unit consumption is assumed to be constant through the years up to 2005 based on the present consumption of 500 l/bed/day, which is the average value of hospitals existant in the study area.

Estimated demand by the above assumption is shown in Table 6.7.

3) Water Demand of Institutions

The water demand of institutions is projected considering number of institutions including government offices, banks, religious establishments, hotels, shops and restaurants.

Existing demand of institutions in Amparai U.C. is found around 100 m^3/day, which is 9 per cent of domestic use. For all the area and year, institutional demand is assumed to be 10 per cent of domestic use, considering the development of public and commercial services.

Table 6.6 Water Demand for Educational Institution

Name of Council	1985		1995		2005	
	No. of Pupil	Demand	No. of Pupil	Demand	No. of Pupil	Demand
Amparai U.C.	4,400	22	6,600	66	10,100	202
Sammanthurai T.C.	1,900	10	2,900	29	4,200	84
Sammanthurai V.C.	700	4	1,100	11	1,700	34
Kalmunai T.C.	3,000	15	5,000	50	7,700	154
Karavahu North V.C.	2,600	13	4,500	45	7,000	140
Karavahu West V.C.	900	4	1.500	15	2,300	46
Karavahu South V.C.	2,100	10	3,000	30	3,800	76
Karativu V.C. Nintavur V.C.	3,800	19	6 200	62	9,200	184
Akkaraipattu North V.C.	2,900	15	4.900	49	7,700	154
Akkaraipattu Central V.C.	4,300	21	7,400	74	11,600	232
Total	26,600 (22,200)	133 (111)	43,100 (36,500)	431 (365)	65,300 (55,200)	1,306 (1,104)

( ) shows water demand in Coastal Area

Table 6.7 Water Demand for Hospital

Name of Council	1981	1985		1995		2005	
	No. of Bed	No. of Bed	Demand	No. of Bed	Demand	No. of Bed	Demand
Amparai U.C.	168	197	99	290	145	430	215
Sammanthurai T.C.	40	44	22	55	28	70	35
Sammanthurai V.C.		-	-	-	-	-	-
Kalmunai T.C.	175	192	96	240	120	300	150
Karavahu North V.C.	-	-	-	-	-	-	-
Karavahu West V.C.	-	-	-	-	-	-	-
Karavahu South V.C.	12	13	7	15	8	20	10
Karativu V.C.	-	-	-	-	-	-	-
Nintavur V.C.	-	-	-	-	-	-	-
Akkaraipattu North V.C.	-	-	-	-	-	-	-
Akkaraipattu Central V.C.	36	29	20	50	25	60	30
Total	431	485	244	650	326	780	440

4) Water Demand of Industries

Water consumption of industries varies according to the type of industry and it is difficult to estimate reliable figures for the future. Existing demand in Amparai U.C. is around 50 m^3/day, which is 4.5 per cent of domestic use.

However, allowing for setting up new industries when adequate and reliable water supplies are available, an industrial use of 10 per cent of the domestic demand for Amparai U.C. and 5 per cent of the same for the others are taken.

6.3.4 Leakage

In the present water supply schemes of Amparai and Kalmunai, no bulk-meters are installed in the systems, and house water meters are installed only for about 12 per cent of the whole service connections in the Amparai scheme area. So, it is impossible to estimate the actual leakage and wastage in the systems.

The leakage, therefore, is assumed at 10 percent for domestic and non-domestic uses for all years in accordance with the practice of the NWSDB applied to the other water supply schemes.

6.3.5 Summary of Water Demand Projection

1) Average water demand projection

The average water demand projections including domestic and non domestic uses are shown in Tables 6.8 through 6.11 for the years 1981, 1985, 1995 and 2005, respectively.

Table 6.8 Water Demand in 1981

Unit: m^3/d

	Domestic (1)	School (2)	Hospital (3)	Institu--tion (4)	Industry (5)	Sub-total (6)	Leakage (7)	Total (8)	Rounded Total
Amparai U.C.	1,040	30	90	100	50	1,310	1,270	2,580	
Sammanthurai T.C.	-	-	-	-	-	-	-	-	
Sammanthurai V.C.	-	-	-	-	-	-	-	-	
Kalmunai T.C.	500	-	-	-	-	500	50	550	
Karavahu N.V.C.	-	-	-	-	-	-	-	-	
Karavahu W.V.C.	80	-	-	-	-	80	10	90	
Karavahu S.V.C.	-	-	-	-	-	-	-	-	
Karativu V.C.	-	-	-	-	-	-	-	-	
Nintavur V.C.	-	-	-	-	-	-	-	-	
Akkaraipattu N.V.C.	-	-	-	-	-	-	-	-	
Akkaraipattu C.V.C.	-	-	-	-	-	-	-	-	
Total	1,620	30	90	100	50	1,890	1,330	3,220	

Table 6.9 Water Demand in 1985

Unit: m^3/a

	Domestic (1)	School (2)	Hospital (3)	Institu--tion (4)	Industry (5)	Sub-total (6)	Leakage (7)	Total (8)	Rounded Total
Amparai U.C.	1,757	22	99	176	176	2,230	223	2,453	2,500
Sammanthurai T.C.	530	10	22	53	27	642	54	706	700
Sammanthurai V.C.	186	4	-	19	9	218	22	240	200
Kalmunai T.C.	865	15	9	86	43	1,105	110	1,215	1,200
Karavahu N.V.C.	750	13	-	75	38	876	88	964	1,000
Karavahu W.V.C.	238	4	-	24	12	278	28	306	300
Karavahu S.V.C.	600	10	7	60	30	707	71	778	800
Karativu V.C. Nintavur V.C.	1,081	19	-	108	54	1,262	126	1,388	1,400
Akkaraipattu N.V.C.	807	15	-	81	40	943	94	1,037	1,000
Akkaraipattu C.V.C.	1,222	21	20	122	61	1,446	145	1,591	1,600
Total	8,036	133	244	804	490	9,707	971	10,678	10,700

Table 6.10 Water Demand in 1995

Unit: m^3/d

	Domestic (1)	School (2)	Hospital (3)	Institu--tion (4)	Industry (5)	Sub-total (6)	Leakage (7)	Total (8)	Rounded Total
Amparai U.C.	3,104	66	145	310	310	3,955	394	4,239	4,300
Sammanthurai T.C.	1,088	29	28	109	54	1,308	131	1,439	1,400
Sammanthurai V.C.	416	11	-	42	21	490	49	539	2,600
Kalmunai T.C.	1,900	50	120	190	95	2,355	235	2,590	2,600
Karavahu N.V.C.	1,676	45	-	168	84	1,973	197	2,170	2,200
Karavahu W.V.C.	544	15	-	54	27	640	64	704	700
Karavahu S.V.C.	1,124	30	8	112	56	1,330	133	1,463	1,500
Karativu V.C. Nintavur V.C.	2,340	62	-	234	117	2,753	275	3,028	3,000
Akkaraipattu N.V.C.	1,856	49	-	185	93	2,183	218	2,401	2,400
Akkaraipattu C.V.C.	2,780	74	25	278	139	3,296	330	3,626	3,600
Total	16,828	431	326	1,682	996	20,263	2,026	22,289	22,300

Table 6.11 Water Demand in 2005

Unit: m^3/d

	Domestic (1)	School (2)	Hospital (3)	Institu-tion (4)	Industry (5)	Sub-total (6)	Leakage (7)	Total (8)	Rounded Total
Amparai U.C.	5,560	202	215	556	556	7,089	709	7,798	7,800
Sammanthurai T.C.	2,068	84	35	207	103	2,497	250	2,747	2,700
Sammanthurai V.C.	850	34	-	85	43	1,012	101	1,113	1,100
Kalmunai T.C.	3,822	154	150	382	191	4,699	470	5,169	5,200
Karavahu N.V.C.	3,450	140	-	345	173	4,108	411	4,519	4,500
Karavahu W.V.C.	1,116	46	-	112	56	1,330	133	1,463	1,500
Karavahu S.V.C.	1,900	76	10	190	85	2,271	227	2,498	2,500
Karativu V.C. Nintavur V.C.	4,588	184	-	459	229	5,460	546	6,006	6,000
Akkaraipattu N.V.C.	3,826	154	-	382	191	4,553	455	5,008	5,000
Akkaraipattu C.V.C.	5,762	232	30	576	288	6,888	689	7,577	7,600
Total	32,942	1,306	440	3,294	1,925	39,907	3,991	43,898	43,900

2) Maximum daily demand projection

Ratio of average daily demand to maximum daily demand is 0.88 to 0.90 according to the statistic data of water demand for municipal water supply system in major cities in tropical countries, such as cities of Jakarta and Bangkok. It is considered that such a high rate is attributable to the insufficient water production for demand. Generally, the rate is low in the systems in localities with seasonal variation of temperature and resort areas, and the rate is high in the systems of large cities and industrial cities.

For this scheme, a rate 0.8, which is a little lower figure, is recommended taking into account the situation of the project area, that is, the area has two distinct seasons, dry and wet, and further the nature of the area is predominantly residential. The maximum daily demand, therefore, is estimated as follows:

$$\frac{\text{Average daily demand}}{\text{Maximum dialy demand}} = 0.8$$

Maximum daily demand = 1.25 x Average daily demand

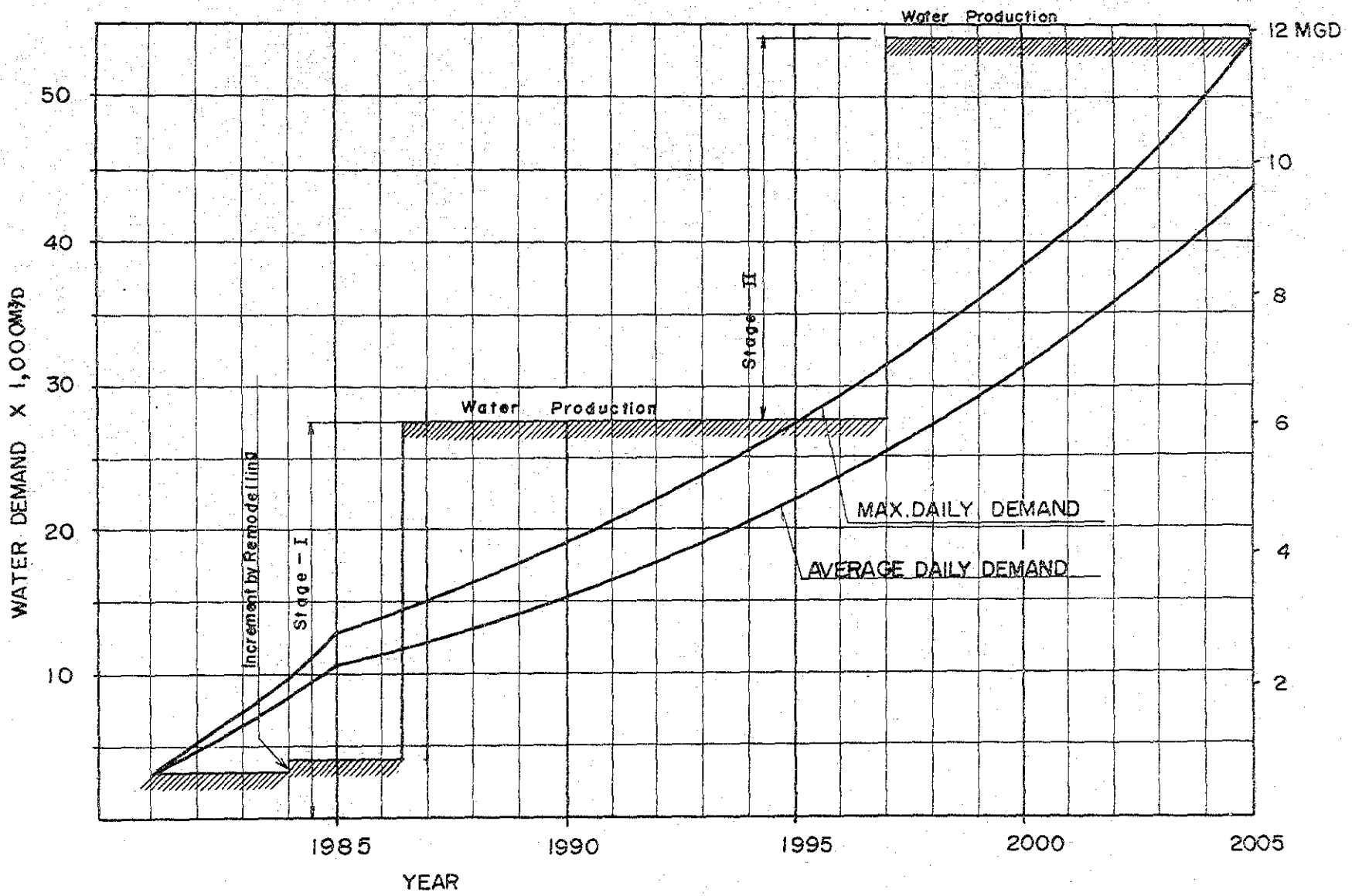
Maximum water demand is summarized in Table 6.12.

Table 6.12 Summary of water demand projection

Particulars	unit	Year		
		1985	1995	2005
Population Served		106,300	172,300	261,100
Domestic Consumption	(1) m^3	8,000	16,800	32,900
Non-domestic Consumption	(2) m^3	1,700	3,500	7,000
Leakage	(3) m^3	1,000	2,000	4,000
Daily Average Demand (4) = (1) + (2) + (3)	m^3	10,700	22,300	43,900
Daily Average per Capita Demand	lpcd	101	129	168
Daily Max. Demand (5) = [(1)+(2)]x1.25+(3)	m^3	13,100	27,400	53,900
Daily Max. per Capita Demand	lpcd	123	159	206

Future Water demand curve is shown in Fig. 6.4.

Fig. 6.4 WATER DEMAND PROJECTION



6.4 Water Source

There are five potential water intake sites for the present scheme for Amparai Group of Towns. Such intake sites will be termed water sources hereinafter. They are located in the Gal Oya river basin, as shown in Fig. 6.5 and 6.6. The water flows down from the Senanayake Samudra reservoir to the Indian Ocean through the said five sources. This reservoir, which is a huge artificial one impounded by rockfill dam constructed in early 1950's for multi-purpose use of irrigation, hydropower and domestic water at an upstream of the Gal Oya river, has a catchment area of 995 km^2, and its gross capacity is 950 million m^3. The plentiful water impounded in the reservoir irrigates the Gal Oya river basin through the year, and will satisfy the proposed water demand for the urban water supply in future.

6.4.1 Potential Water Sources

The said five sources are two tanks of Kondavattavan and Amparai and surface water flowing at three anicuts of Kallarachel, Sambuveli and Kaliodai. The resume of the sources is described as follows:

1) Tanks

Kondavattavan tank and Amparai tank are considered as sources of the water supply scheme for Amparai area. The water of 42 m^3/sec discharged from the Senanayake Samudra reservoir to Left Bank Main Channel (LBMC) flows down to Aligalge tank and Himidurawa tank and then the water of 7.0 m^3/sec flows into Kondavattavan tank, and furthermore the water of 0.5 m^3/sec flows into Amparai tank from Kondavattavan tank. The net capacity of Kondavattavan tank is 11.4 million m^3 and Amparai tank 8.8 million m^3, as described in detail in Appendix B.

Considering sufficient inflow rates and net capacities of tanks, the proposed water demand of 0.12 m^3/sec for Amparai area in the year 2005 will be duly available. Particularly, use of Amparai tank has been transferred to an exclusive use for the water supply scheme from irrigation use.

Fig. 6.5 TANKS AND ANICUTS PROPOSED FOR WATER SOURCES

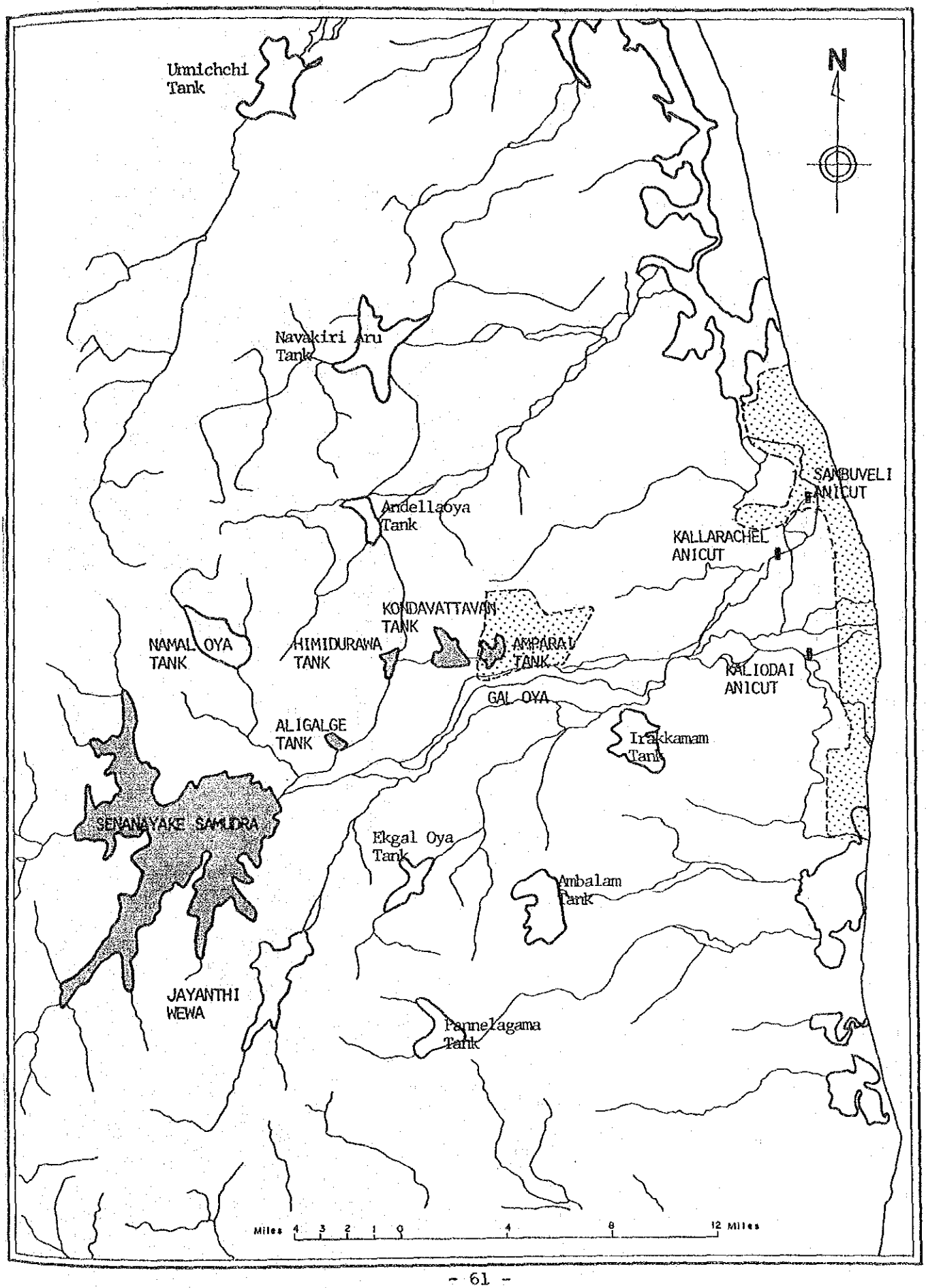
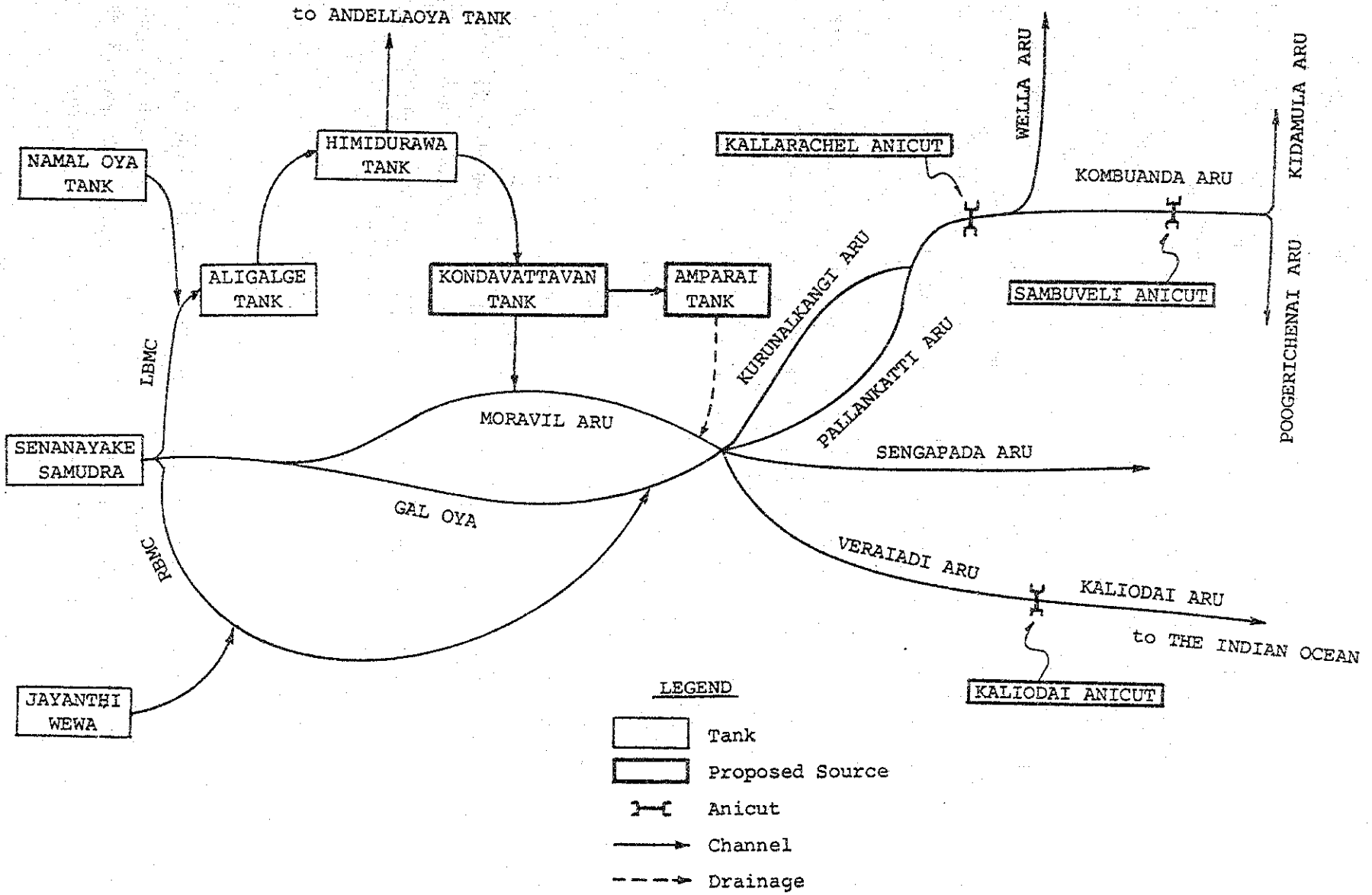


Fig. 6.6 Schematic Water Flow Chart



2) Surface Water at Anicuts

Surface water at anicuts of Kallarachel, Sambuveli and Kaliodai is considered as sources of water supply scheme for Coastal area.

The water of 4.5 m^3/sec discharged from the Kondavattavan tank to the Moravil Aru river irrigates paddy and sugar cane fields, and then flows down to the Indian Ocean through Kallarachel anicut and Sambuveli anicut, as described in detail in Appendix B. The water flow is stable through the year. Due to lack of flow rate data of the rivers, actual flow rates were measured by the Team in March, 1982, which fell on a drought season, and they were 1.5 m^3/sec at Kallarachel anicut and 1.0 m^3/sec at Sambuveli anicut respectively.

The water of 17 m^3/sec discharged from the Senanayake Samudra reservoir to Right Bank Main Channel (RBMC) flows down through paddy and sugar cane fields and ultimately to the Indian Ocean through Kaliodai anicut. The water flow is stable through the year. Actual flow rate was checked by the Team during the initiation period of irrigation for paddy fields and it was found at 0.3 m^3/sec at Kaliodai anicut, as described in detail in Appendix B.

Considering the above flow rates and higher priority of water allocation for drinking use, the planned water demand of 0.56 m^3/sec for Coastal area in the year 2005 will be available at Kallarachel anicut and/or Sambuveli anicut, and water demand of 0.20 m^3/sec for Akkaraipattu area will also be assured at Kaliodai anicut in case Akkaraipattu area separately be supplied. It is necessary to obtain the water right for the water supply scheme from the Agencies concerned.

6.4.2 Groundwater

The groundwater is considered to be prospective as the water source if it is available. Hydrogeological data of deep wells in the project area is scarce at present. Team's observation on the topographical feature reveals that there is little potentiality on artesian groundwater. Con-

sidering the groundwater project set up in 1979 to dig deep wells in hard rock, the groundwater is not recommendable for the proposed scheme as a permanent water source.

Besides, the groundwater from shallow aquifer contains high concentrations of iron and ammonia nitrogen, so that treatment process such as aeration and filtration will be necessary for piped water supply system. The construction cost thereof seems to be not necessarily inexpensive compared with that of using surface water. Furthermore, it is not appropriate to utilize poor yields of wells for the public water supply, because it is costly to sink many wells and inconvenient to operate such numerous wells.

6.5 Water Quality

6.5.1 Characteristics of Water Quality

1) Water Quality of Tanks

The water quality of the Amparai and Kondavattavan tanks is shown in Table 6.13. Characteristics of the water quality are summarized as follows:

(a) turbidity is high although there seems no inflow of rainfall run-off,

(b) the tank water is in the stage of excessive saturation of dissolved oxygen,

(c) the value of pH is high,

(d) the water is coloured greenish-yellow,

(e) the transparancy is low ranging from 20 cm to 50 cm,

(f) the water has musty smell,

(g) the water contains slightly high contents of iron and ammonia nitrogen.

Table 6.13 Water Quality of Tank Water

Items		Amparai Tank				Kondavattavan Tank	
Sampling Date		2 Mar. 1982		9 Mar. 1982		2 Mar. 1982	9 Mar. 1982
Water Depth Sampled		0^m	0.8^m	0^m	0.8^m	0^m	0^m
Water Temperature	°C	31.0	29.5	31.5	30.5	29.6	30.5
pH		7.6	7.4	8.8	8.6	8.6	8.8
Turbidity	degree	75	100	75	75	33	30
Colour	"	20	20	25	25	15	10
Alkalinity	mg/l	37	35	33	33	33	30
Potassium Permanganate Consumed	"	55.3	55.3	-	-	37.9	-
Nitate Nitrogen	"	ND	ND	-	-	ND	-
Ammonia Nitrigen	"	0.16	0.16	0.10	0.10	0.10	0.07
Hardness	"	28	27	26	25	26	24
Chloride Ion	"	20	20	18	20	8	8
Phenols	"	ND	ND	-	-	ND	-
Iorn	"	0.20	0.25	0.40 (0.10)	0.40 (0.10)	0.15	0.25 (0.10)
Manganese	"	0.02	0.02	0.04	0.05	0.02	0.04
Chronium	"	ND	ND	-	-	ND	-
Copper	"	ND	ND	-	-	ND	-
Coliform Group	Nos/ml	1	0	0	0	9	2
Total Colonies	"	25	37	243	504	62	150
Odour		musty smell	musty smell	musty smell	musty smell	musty smell	musty smell
Dissolved Oxygen	mg/l	8.2	6.8	9.0	8.8	7.0	7.0

Note: ND : Not detected

( ): For Dissolved iron

(a) to (e) may have been caused by a tremendous growth of plankton algae due to eutrophication of the tank, and (f) is caused by Actinomycesor specific plankton algae (Phormidium etc), and (g) is caused by dissolution of iron and ammonia nitrogen deoxidized under non-oxygen status which is caused due to non-existence of dissolved oxygen being consumed by dead Salvinia and plankton algae in the tank.

In the process of treating of this raw water, the following will be anticipated:

(a) dosing rate of alum will be high,

(b) sedimentation will be inefficient due to light floc,

(c) filter media will be clogged by uncoagulated plankton,

(d) dosage of chlorine rate will be high due to increase of ammonia nitrogen.

The water quality of the Kondavattavan tank is almost same as that of the Amparai tank. Turbidity is 1/3 to 1/4 of that of the Amparai tank and eutrophication of the tank is not so serious as the Amparai tank.

2) Water Quality of Anicut River Water

The water quality of river water sampled from Kallarachell, Kaliodai and Sambuveli anicuts which are considered as future water sources is shown in Table 6.14.

Table 6.14 Water Quality of Anicut Water

Anicut		Kallarachel Anicut		Kaliodai Anicut		Samkuveli Anicut	
Sampling Date		1982.3 2	1982.3 16	1982.3 2	1982.3 16	1982.3 2	1982.3 16
Water Temperature	°C	29	29	33	29	30	29
pH		7.2	7.8	7.4	7.2	7.4	7.4
Turbidity	Degree	25	20	25	25	45	25
Colour	"	10	10	10	20	15	10
Alkalinity	mg/l	52	51	45	48	60	47
Potassium permanganate Consumed	"	23.7	-	23.7	-	23.7	-
Nitate Nitrogen	"	0.2	-	0.6	-	0.2	-
Ammonia Nitrogen	"	0.10	0.07	0.07	0.05	0.10	0.07
Hardness	"	38	40	34	33	43	36
Chloride Ion	"	13	15	11	12	14	12
Phenols	"	ND	-	ND	-	ND	-
Iron	"	0.85	0.40	1.50	0.60	1.50	0.30
Dissolved Iron	"	-	0.25	-	0.40	-	0.25
Manganese	"	0.03	0.08	0.04	0.04	0.03	0.04
Chronium	"	ND	-	ND	-	ND	-
Copper	"	ND	-	ND	-	ND	-
Coliform Group	Nos/ml	1	0	0	5	0	0
Total Colonies	"	175	806	54	207	154	103
Dissolved Oxygen	mg/l	5.4	6.6	6.2	6.0	6.0	5.0

Note: ND - Not detection

6.5.2 Coagulation Test

Coagulation test of the raw water sampled from two tanks and three anicuts described in the previous section was performed during the field survey. The results are stated as follows:

1) Tanks

Amparai tank

Table 6.15 shows results of the coagulation test for water of the Amparai tank. Taking 1.0 minute for rapid mixing and 10 minutes for slow mixing, relatively good coagulation results were obtained for removals of algae, turbidity, colour and iron with the alum dosage 75 mg/l and chlorine 3 to 5 mg/l. However, it was unable to remove musty smell by means of pre-chlorination and rapid sand filtration processes.

From the characteristics of the raw water, some problems may, it is feared, occur in the process of treatment. Anticipated problems are as below:

a. Rather high dosage rate of alum, though turbidity is low, will be necessary.

b. Efficiency of sedimentation may not be good, because major component of turbidity is plankton algae and floc is light. Accordingly a retention time as long as possible shall be taken for sedimentation basin.

c. Rather high dosage rate of chlorine will be necessary, for high contents of organic matters and ammonia nitorogen consume much chlorine.

d. As musty smell is severe, special consideration shall be made for removal of the odour.

Kondavattavan tank

Table 6.15 shows results of the coagulation test for water of the Kondavattavan tank. The result shows almost same troubles as the Amparai tank; however, its degree is lower due to the lower condition of eutrophication than the Amparai tank. Appropriate dosage of alum and chlorine was 30 mg/l and 3 mg/l respectively against those of 75 mg/l and 5 mg/l for the Amparai tank water.

2) Anicuts

Table 6.16 shows the results of coagulation tests for raw water sampled from three anicuts; Sambuveli, Kallarachel and Kaliodai anicuts. The coagulation shows better effect than that of the tank water with lower dosage rates of chlorine and alum. As mentioned in the previous section 6.5.1 Characteristics of Water Quality, the raw water has slightly higher values of turbidity and colour, organic matters and iron contents, and coliform group than the drinking water standard. However, these substances will be removed to the values less than the standard values by pre-chlorination (1.6 mg/l), coagulation (20 mg/l of alum dosage), flocculation, sedimentation and filtration process.

In case turbidity rises, it will be coped with by means of increasing the alum dosage. If the turbidity exceeds 1,000 degrees or more, it will be needed to take such an emergency measure as to reduce intake of raw water.

6.5.3 Treatment Process

Based on the characteristics of raw water and the results of coagulation tests, the treatment process as shown in the following flow charts are recommended, taking into consideration the reliability of removal of odour and easiness of operation and maintenance, for the water of the tanks and anicuts. The detail description is attached in Appendix C.

Table 6.15 Coagulation Tests for Tank Water

As of March 1982 unit: mg/l

Sample No.	Amparai Tank								Kondavatavan Tank					
Items	1	2	3	4	5	6	7	8	1	2	3	4	5	6
Alum Salfate Dosage	0	30	40	50		75			0	30			50	
Chlorine Dosage	0	3	3	0	3	0	3	5	0	0	3	5	0	3
pH	7.0	-	-	6.4	6.6	5.8	5.8	5.8	8.8	6.2	7.0	6.8	6.2	6.2
Turbidity (degree)	80	100	75	55	42	30	25	23	35	35	23	25	25	23
Colour (degree)	30	-	-	20	7	7	5	5	10	7	2	2	8	2
Alkalinity	35	-	-	18	19	8	7	5	30	20	22	23	13	13
NH_4-N	0.33	-	-	0.33	0.07	0.33	0.07	0.03	0.10	0.10	0.03	0.03	0.10	0.03
Iron	0.40	-	-	0.30	0.10	0.15	0.10	0.05	0.25	0.20	0.10	0.10	0.10	0.10
Odour	musty	musty	musty	musty	musty	musty	musty	musty	musty	musty	musty	musty	musty	musty
Total Number of Algae Plankton (group/ml)	347,000	-	-	-	-	147,600	-	-	-	-	-	-	-	-
Residual Chlirine	-	-	-	-	0	-	0.2	0.3	-	-	0.1	1.5	-	0.2
T-P *	0.33	-	-	-	-	0.19	-	-	-	-	-	-	-	-

Note : * Test in Tokyo

- Not analyzed

Table 6.16 Coagulation Tests for River Water

As of March 1982

unit: mg/l

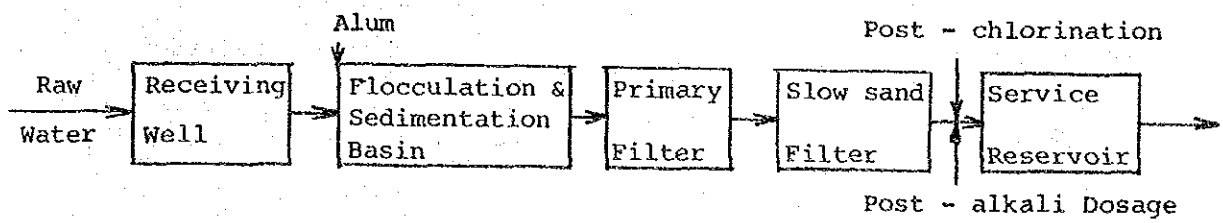
Sample No.	Sambuveli Anicut				Kallarachel Anicut					Kaliodai Anicut					
Items	1	2	3	4	1	2	3	4	5	1	2	3	4	5	6
Alum Salfate Dosage	0	20		30	0	20			30	0	10	20			30
Chlorine Dosage	0	0	1.6	1.6	0	0	1.6	3.2	1.6	0	1.6	0	1.6	3.2	1.6
pH	7.4	6.8	6.8	6.6	7.2	6.8	6.8	6.8	6.8	7.8	7.2	7.0	7.0	7.0	6.8
Turbidity (degree)	20	10	5	5	25	10	5	5	5	20	21	10	5	5	5
Colour (degree)	10	5	2	2	20	10	7	5	7	10	7	5	2	2	2
Alkalinity	47	39	38	36	48	38	40	38	33	51	46	48	48	48	41
NH_4-N	0.07	0.05	0.02	0.02	0.05	0.03	0.02	0.02	0.02	0.07	0.05	0.05	0.05	0.05	0.05
Iron	0.30	0.10	0.10	0.10	0.60	0.20	0.10	0.15	0.15	0.40	0.30	0.15	0.10	0.10	0.10
Manganese	0.04	0.05	0.05	0.03	0.04	0.04	0.04	0.04	0.04	0.08	0.06	0.04	0.06	0.05	0.06
Odour	musty	slightly musty	slightly musty	slightly musty	musty	slightly musty	slightly musty	slightly musty	slightly musty	musty	slightly musty	slightly musty	slightly musty	slightly musty	slightly musty
Residual chlorine	-	-	0.3	0.4	-	-	0.1	2.0	0.4	-	0.4	0	0.4	1.7	0.4

1) Flow Chart for Process

Tanks

The flow chart of treatment process for the Amparai and Kondavattavan tank water is shown in Fig. 6.6. For removal of odour, some alternatives such as activated carbon dosage, ozonation and biological oxidation processes were compared. As a result of the comparison, it was found that dual-stage filtration is the best way of the removal of odour, for this method is most economical, reliable and easy in opeation and maintenance.

Fig. 6.6 Flow Chart of Treatment Process for Tank Water



a. Primary filtration:

To remove suspended particles of the plankton algae leaked from coagulation and sedimentation process. Filtration rate sdoptable is 100 m/d to 120 m/d (4.2 to 5.0 $m^3/m^2/hr$).

b. Secondary filtration (slow sand filtration):

To remove musty smell, organic matters, ammonia nitrogen, iron and manganese. Filtration rate adaptable is 5 m/d to 15 m/d (0.2 to 0.62 $m^3/m^2/hr$)

c. Post-chlorination

To sterilize residual bacteria. As ammonia nitrogen is removed by the slow sand filter, a rather little dosage of chlorine may suffice.

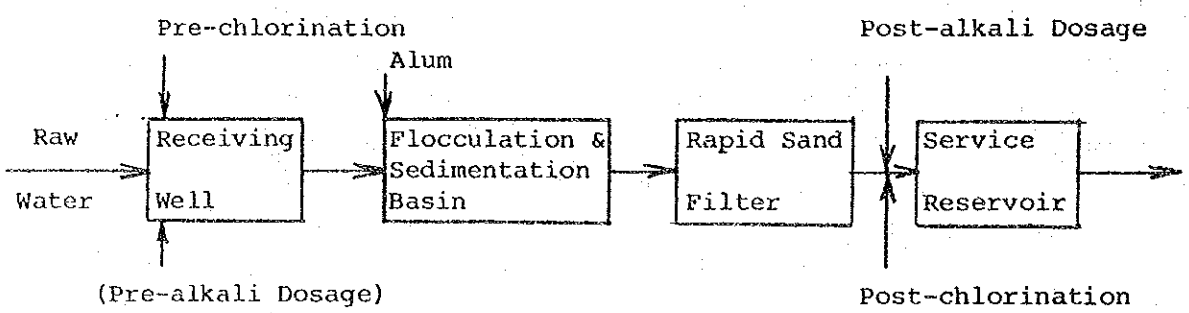
d. Post-alkali dosage

To correct pH, and to prevent corrosion of pipe, post-alkali dosage is required.

Anicuts

The treatment process to be applied for the anicut water is shown in Fig. 6.7. The conventional process of pre-chlorination and rapid sand filtration may be adopted for the treatment of water of the anicuts.

Fig. 6.7 Flow Chart for Treatment Process for Anicut Water



Note: ( ) for high turbidity

a. Pre-chlorination:

To oxidize organic matters, iron and manganese.

b. Pre-alkali dosage:

To apply alkali as coagulation aid for high turbidity.

c. Post-alkali dosage:

To correct pH for prevention of corrosion of pipe.

d. Post-chlorination:

To apply additional chlorine after consumption of pre-chlorine.

6.5.4 Chemical Dosage Rate

Based on the flow chart of treatment process and the results of coagulation test, the chemical dosage rate is estimated for the tank and anicut water as shown in Tables 6.17 and 6.18.

Table 6.17 Chemical Dosage Rate for Tank Water

unit: mg/l

	Amparai Tank			Kondavattavan Tank		
	Alum.	Post-alkali $Ca(OH)_2$	Post-chlorine	Alum.	Post alkali $Ca(OH)_2$	Post-chlorine
Maximum	90	15	3	65	15	3
Average	55	6	2	50	10	1

At the result of coagulation test, 75 mg/l of alum dosage and 12 mg/l of lime dosage were recommended during four months period in a year except low turbidity as shown in Table 5.1.3 in Appendix-C. Considering to dose chemicals all through the year, however, the dosage rates of chemicals shown in the above Table 6.17 are recommendable for annual average turbidity of 50 degree which is presumed from past records available.

Table 6.18 Chemical Dosage Rate for Anicut Water

unit: mg/l

	Alum.	Pre-alkali $Ca(OH)_2$	Pre-chlorine	Post-alkali $Ca(OH)_2$	Post-chlorine
Maximum	100	(10)	5	35	1
Average	30	0	2	10	0.5

( ) : for high turbidity