STUDY OF BHARATHAPUZHA BASIN WITH SPECIAL REFERENCE TO CHECKDAMS

By

PREMRAJ, P.

PROJECT REPORT

Submitted in partial fulfilment of the requirement for the degree

Bachelor of Technology
in
Agricultural Engineering

Faculty of Agricultural Engineering and Technology
Kerala Agricultural University

Department of Irrigation and Drainage Engineering

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY

TAVANUR - 679 573, MALAPPURAM

KERALA, INDIA

1999

DECLARATION

I here by declare that this project report entitled **"STUDY OF BHARATHAPUZHA BASIN WITH SPECIAL REFERENCE TO CHECKDAMS"** is a bonafide record of project work done by me during the cource of project and that the report has not previously formed the basis for the award to me of any degree, associateship, fellowship or other similar title of any other university or society.

PREMRAJ, P.

Tavanur

6th April 1999

CERTIFICATE

Certified that this project report entitled **"STUDY OF BHARATHAPUZA BASIN WITH SPECIAL REFERENCE TO CHECKDAMS"** is a record of project report done by PREMRAJ,P. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

SUSEELA,P.

Project guide

Assistant professor

Department of IDE

KCAET,Tavanur.

Tavanur

6th April 1999

ACKNOWLEDGEMENT

With ecstasy, let me express my sincere gratitude and affinity of my much respected guide Smt. SUSEELA,P.; Assistant professor, Department of IDE .It is the fact that her animated guidance, appraisal of the work at the hour of need, creative criticism, above all, creation of self actualisation and immense interest in the subject, led to the fulfilment of my work.

I express my gratitude to Dr.K.John Thomas, Dean, KCAET, Tavanur for his valuable advices.

I gratefully acknowledge the help rendered by Sri.T.N.N . Bhatathiripadu, Rtd. Chief Engineer, Kerala Water Authority, for all the help rendered during the early stages of this work.

I sincerely acknowledge the timely help and co-operation rendered by Madhavan,K. Chief Engineer(Rtd.),Central Water Commission and Anirudhan,o. Geotechnical Engineer, for the completion of this work.

I also express my heartful thanks to Haridas,o.p. Assistant Engineer, Minor Irrigation section, Mannarkkad, with out whose help completion of this work would have been impossible.

Also, I affectionately remember the support and inspiration given by my parents and brothers.

I avail this opportunity to express my sincere thanks to National Computer Centre, Kuttippuram for the neat typing of this project report. I also express my indebtedness to Jayakrishnan, Najash Babu, Vinayak, Biju and all my friends at KCAET who have helped me.

Above all , I humbly bow my head before the Almighty for all the blessings, showered upon me.

PREMRAJ, P.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

SYMBOLS AND ABBREVIATIONS USED

Cm	-	Centimetre
cm^2	-	Square Centimetre
etc.	-	execetra
Fig.	-	Figure
gm	-	gram
m^3	-	Cubic metres
gm/m^3	-	gram per cubic metres
hrs	-	hours
ha	-	hectores
hp	-	Horse power
i.e.	-	That is
Kg	-	Kilogram
Kg/cm^2	-	Kilogram per square centimetres
log	-	logarithm
m	-	metre
ml	-	milli litre
mm	-	milli metre
MSL	-	Mean sea level
NE	-	North East
SW	-	South West
Qtl	-	Quintal
%	-	percentage
No	-	number
S.N.	-	Serial number
sq.km	-	Square kilo metres
Rs.	-	Rupees
/	-	per

INTRODUCTION

1.1. General

Kerala is relatively small state in India, which forms just 1.3 % of the total land area of the country. Kerala falls between 8° 18' and 12° 22' N latitude and 74 ° 52' and 77 ° 22' east longitude. Based on Physiography, Kerala can be divided in to three zones - eastern highland, western low land central midland. The width of the state varies from 15 to 120 km.

Forty four rivers with lengths more than 15 km originate from the Western Ghats. Out of which 41 flows towards the west and join the Arabian sea. The remaining three rivers flow towards the east to the neighbouring states and join the Cauvery system and drain into Bay of Bengal.

The average annual rainfall of the state is estimated by 3000mm. The spatial and temporal distribution pattern of rainfall is mainly responsible for the frequent floods and droughts of Kerala. The average annual rainfall in lowland of Kerala ranges from 900 mm in south to 3500 mm in the north. In the midland annual rainfall ranges from 1400 mm in the south to 4000 mm in the north. In the highlands annual rain fall varies from 2500 mm in the south to about 6000 mm in the north. About 60% of annual rainfall in the state is received during the south-west monsoon (June-August), 25% during North-East monsoon (Sept - Nov) and the remaining during the summer period.

With about 3000mm average rainfall, chains of back water bodies, reservoirs, tanks, ponds, springs and wells, Kerala is considered by many as the land of water and a feeling of ceritentment is there in everybody's mind. Yet Kerala is frequently facing severe droughts followed by acute drinking water scarcity for the last two decades. The rivers hardly contain any water during six months in a year . Only a few reservoirs get filled up even in the monsoon. During the summer, water level goes down to the silted up bottom in many cases. More and more wells are getting dry in summer and there seems to be an all round anxiety to know what is in store for the next month.

The surface runoff and ground water recharge of Kerala are only 60% and 40% of those of Tamil Nadu, and 44% and 77% those of Rajasthan. Hence eventhough unit land of Kerala receives 3 to 5 times more rainfall than many other states, the total annual surface and ground water potentials are very low compared to that of many other states of the country.

Compared to the national average, unit land of Kerala is receiving 2.5 times more rainfall, but same unit land of Kerala has to support 3.6 times more population. Hence for self sufficiency, unit land of Kerala has to provide 3.6 times more drinking water and associated water requirements. Percapita resource availability is the better indication of the richness of the area than the resource availability in unit land. Percapita of water on national level is 18000 litre per year where as in Kerala it is only 13000 per year. From this one can understand that the plentiness of Kerala is only apparent and not real. Due to steep and undulating topography, rain water is not much retained on the land in comparison with other states, there by obviating the advantages of having high rainfall. The rain water reach the sea within 24 to 48 hours due to this steep gradient. The total runoff of all the 44 rivers is estimated as 78041 Mm^3 of which 70,323 Mm^3 is Kerala's contribution. Only 5% of this is believed to be converted in-to ground water resources which is somewhere between 5,900 Mm^2 and 8130 Mm^3 Deforestation and increasing population also contribute to dry river beds and increasingly dry wells in the state.

As per national norm rivers with drainage areas more than 20,000 and 2000 sq km are termed as major and medium rivers respectively. Rivers with less than 2,000 sq km are termed as minor rivers. In Kerala a stream having length more than 15 km is considered as a river. Hence the number 44 must not mistify any body and should not bias the decision makers. The number is irrational, arbitrary and misleading. Kerala does not have a single major river. She has only four medium rivers. The combined discharge of these four rivers are less than half of that of Krishna. Remaining 40 rivers are minor rivers, the combined discharge of all of them together is only about one third of the Godavari.

Due to the topographical and financial constraints, Kerala could not harness the rain water for irrigation. There is no scope for storing the monsoon water in times or bunds as being done in other states due to Kerala's topographic features and lack of availability of wastelands. The development of groundwater in Kerala was not thought of seriously in all these years due to the misconceived notion that the state's entire water requirement would be met by the fairly rich annual rainfall and high density of rivers. Now the situation has changed and different sectors like community water supply, industries , agriculture etc. have also increased the demand of water. The three main agencies correctly involved with the exploration and exploitation of ground water are

1. State ground water department stabilised as a part of the directorate. In agriculture during 1967 and increased into an independent department since 1978.
2. Public health engineering department
3. Central ground water board which is engaged in regional ground water surveys throughout the state.

If the flood water can be stored by some means, it can be used for irrigation during summer times. For a state like Kerala, practical method has to be evolved to harness or to impound a part of the wasted flood so as to utilise the same during draught periods for irrigation and water supply.

1.2. Bharatha Puzha River

Rivers have been the pivotal points around which the worlds civilization have originated. The Bharathapuzha is the second longest river in Kerala after the Periyar originating from the Anamalai hills in the Coimbatore district in Tamilnadu at an elevation of 1964 1964 msl. This 209 km long river flows through districts of Coimbatore Palakkad, Malappuram and Thrissur to join the Arabian sea at Ponnani (It flows through 11 Taluks about 4000 villages). In fact about 175 villages are totally depending on this river for their drinking water supplies. This river has 20 tributaries of which four, the Gayathri puzha, Kannadipuzha (also known as Chittur Puzha and Amaravathi), Kalpathi Puzha and Thootha puzha are major ones. About 40 km of the river is navigable. The Bharatha Puzha has a total basin are of 6186 sq km with an average yield of 7478 Mm^3. Two thirds of the river basin is in Kerala

(4400 sq km) and remaining 1,78652 sq km lies in Tamilnadu. The river basin sets on average annual rainfall of an estimated 5082.9 Mm^3.

There are about 9 medium irrigation projects on this river, some of which have commissioned. These are mainly intended for second crop paddy cultivation. The ratio between ultimate potentiality and actual area under irrigation is very high which indicates low irrigation efficiency. Infact Kerala has one of the lowest irrigation efficiency (30%) . The water requirements has increased manifold due to the increase in population. In 1951 the population of River basin was 90000 which in 1997 had grown to 2000000 which is an increase of 222% over a period of 46 years. The increasing pressure on land for agriculture activates naturally has its effects on river systems and water use.

Along with increasing use of water, there is the parallel problem of deforestation and growing acrease for plantations, which affect the retention and water use. Along the Bharathapuzha a study along Mangala Puzha - Gayathri Puzha basin alone has indicated massive loss of forest area where as in 1905, 60% of the basin was under forest. Between 1905 and 1973 about 49% of forest have been removed and in 1965 the forest area was 9.74% and in 1973 this had been reduced to 5.62% of the total basin area. The destruction of forest in the Nelliampathy region which is in the catchment area of Bharathapuzha has resulted in the thinning of the river here even in the monsoon months. The total 826 sq km of attappadi region in the palakkad district, 507 sq km has already become wasteland because of forest destruction.

Drinking water has become a scare commodity along the Bharathapuzha and many wells have dried up in the villages along the course of river. Water scarsity begins in most places by March and in some places even as early as December. This scarcity lasts till the arrival of south west monsoons in June. Some of the major tributaries of this river are even showing signs of disappearing. These tributaries do not even hold the water during the monsoons. Kalpathy which is a major tributary of Bharathapuzha is covered with a thick growth of shrubs on its sand bed, sans water.

Industrial pollution posses another of the major threats to the river. The pollution has even contaminated the well water along the reaches of the river.

Sand mining is another major hazard posed to the river, and still continues unabated. This river bed is estimated to have gone down by more than a metre, mainly along the stretches of Cheruthurithy and Kuttippuram. Further deterioration of this situation has caused salt water intrusion at the lower reaches of the river. Many of the bridges across this river and its tributaries are in danger of collapse as their foundations have been exposed, and deep cracks have been developed in many of them. Chronic mining has even caused to the river to take a diversion at Thirunavaya.

To solve some of these problems a number of activists have grouped to introduce certain measures and to introduce the local bodies and the government to take some prompt actions.

1. As a part of this 14 check dams and subsurface dams have been proposed to construct along the river .
2. As a corollary also local bodies are being pressurized to limit and control sand mining. To discourage illegal mining it is proposed to build ramparts at selected points to prevent trucks driving down to the river beds. It is proposed also to ban sand mining atleast one kilimeter from places where water is used for drinking and irrigation purposes.
3. The local bodies and government are being addressed to enforce strictly various ordinances in existence for controlling effluent discharges, especially by industrial units to water bodies. The recalcitrant units licenses are to be revoked. The local bodies are to be discouraged from using the river and tributaries as dumping grounds. These local bodies must be encouraged to set up other disposals systems and units.
4. There are numerous shrubs growing along the river bed and it is planned that these should be removed as well as patches where newones are likely to sprout out.
5. The chamravattom regulator-cum bridge proposed at the lower reaches of the river (5 km from where it joins the sea) is expected to control the saline intrusion especially during the summer months. It is urgent under the present circumstances to expedite this construction.

6. There should legislation introduced with regard to extraction of water for various requirements especially with regard to irrigation needs. Water intense cropping patterns, especially in the upper reaches, and diverting water for these requirements have dwindled the rivers flow to mere trickles in the lower reaches.
7. Afforestation especially in the denuded upper reaches is another aspects for urgent considerations and action. The steep and slopping terrain of the region tends this an increased importance. Prevention of further deforestation especially in the catchment areas is another step that is being placed urgently before government.
8. Encroachers along the riverbanks must be evicted and boundaries clearly demarcated.
9. Formation of Bharathapuzha River water authority has been mooted earlier, but is yet to be established through legislation.
10. To create water literacy especially among the people living along and depending on the river.
11. The emphasis on the protection of river has to be placed on "conservation" along with the protection against environmental degradation.

Among the fourteen sites selected, which are found to be suitable for the construction of check dams and subsurface dams , three has been completed which used resources provided by the central government, and labour mobilized by the residents of the area. A local survey conducted on these sites shows that, during this torrid and parching summer that just passed, the wells in the catchment reach of these check dams had water in them, atleast for drinking purpose. These were used to dry up even during the beginning of the summer time previously. It is expected to improve in the following years.

The saving of Bharathapuzha could well pay the way for the saving of the other rivers of Kerala all of which are faced with the same fate.

The check dams and sub-surface dam structures are simple, cheap eco-friendly. In the contrast to the conventional method of storing water in the open reservoirs by building a dam across the river to collect the surface runoff, the subsurface dam arrest the subsurface flow of water and store it below the ground surface. One of the proposed site at Thrangali kadavu, in Vaniyankulam panchayath was specifically chosen for the study and construction of subsurface dam. Bentonite slurry is used to construct the impermeable layer to arrest the subsurface flow. Bentonite suspension, are thixotropic, and behave like a fluid when in movement, but form a "gelly" when stationery. The construction is simple and required less time . And also it does not require the dewatering of ground.

The objectives of the present study include

1. General study of Bharathapuzha basin
2. Recconaisance survey of the perticular area, Thrangali kadavu, selected for the construction of the sub-furface dam.
3. Collection of the details regarding the water requirement for the irrigation and drinking water needs of the proposed area.
4. Construction details of sub-surface dam.
5. Cost analysis.
6. Effectiveness of the sub-surface dam.

REVIEW OF LITERATURE

In this chapter an attempt is made to give brief review of literature relevant to the topic of study undertaken in the parts.

2.1. Bharatha Puzha River

The Bharathapuzha is the second longest river in Kerala after the Periyar originating from the Anamalai hills in the Coimbatore district in Tamilnadu at an elevation of 1964 1964 msl. This 209 km long river flows through districts of Coimbatore Palakkad, Malappuram and Thrissur to join the Arabian sea at Ponnani (It flows through 11 Taluks about 4000 villages). In fact about 175 villages are totally depending on this river for their drinking water supplies. This river has 20 tributaries of which four, the Gayathri puzha, Kannadipuzha (also known as Chittur Puzha and Amaravathi), Kalpathi Puzha and Thootha puzha are major ones. About 40 km of the river is navigable. The Bharatha Puzha has a total basin are of 6186 sq km with an average yield of 7478 Mm^3. Two thirds of the river basin is in Kerala (4400 sq km) and remaining 1,78652 sq km lies in Tamilnadu. The river basin sets on average annual rainfall of an estimated 5082.9 Mm^3.

2.2. Grouting

Grouting is the term used to describe the method of injecting a fluid substance into rock fissures or into a soil either to provide improved stability or reduce permeability. The grout substance can be selected from a range of materials such as cement , clay suspensions in water, chemical solutions or even emulsions of bitumen and water. Grouting has application in

1. Sealing pockets and lenses of permeable or unstable soil or rock prior to escavation of tunnel heading.

2. Sealing the base of excavation, coffer - dam or caisson founded on a permeable stratum.

3. Grouting in ground anchors for sheet pile walls, retaining walls, stabilising rock cuttings, tunnel etc.

4. Repairing

   a. The ground underneath a foundation may be strengthened with the injection of suitable grout.

   b. A new damp proof course can be formed in a layer of brick work by using a chemical grout.

   c. Cracks and structural diffects on building masonry can be filled .

5. Filling the voids between the lining and rock face in tunnel works.

6. Forming a "grout curtain " in layers of permeable strata below a dam and so effectively sealing of any flow from the storage side.

7. Grouting up the tendons in prestressed post tensioned concrete.

The principle of grouting is to introduce a substance to fill the voids in a soil or the fissures in a rock by pumping fluid down a small diameter tube place in a drill hole. The depth of boring controls the thickness of the layer to be grouted and as each stage is completed the bore hole is lengthened and further layer is grouted, and so on until the design depth is reached.

2.3. Grouts fall into the following categories

a) Suspension of soil particles in water, such as clays, cements, bentonite, plaster, pulverised fuel ash(PFA), lime etc

b) Emulsions such as bitumen in water.

c) Solutions, which react after injection to form in soluble precipitate.

The principles to follow in choosing the grout are

i. The grout must be able to penetrate the voids of mass to be injected.

ii. The grout should be resistant to the chemical attack when in place.

iii. The grout should be able to develop sufficient shear strength to withstand the hydraulic gradient imposed during injection and on flowing ground water.

Table 1. shows recommendation for application of grouts in various situations and Table 2. shows physical properties of clay grouts.

Table 1. Grout Types and Applications

PFA	suspensions	Mass filling in very coarse soils and rock fissures
Cement		Mass filling in very coarse soils and rock fissures Plus Ground strengthening
Clay		Mass filling in medium coarse soil and impermeability improvement
Clay/Cement		Similar to clays, Plus added strength
Emulsions		Impermeability improvement
Solutions, Single Shot		Permeability and /or strength improvements in medium coarse soils
Solutions, Double shot		As for single shot, with additional controller set time, also suitable in fine soil

Table 2. Physical properties of Clay Grouts

Type of Grouts	water/ Solids	Clay/ Cement	Density (Kg/m^3)	Crushing Strength (N/mm^2)	Setting Time (Hr)	Comments
Clay- Chemical	20	-	1100	-	Varies	Fluid
Clay-Cement	7	0.5	1100	0.2	24	Thin Slurry
Cement-Bentonite Clay	0.3	0.05	1600	5	24	Thick Slurry

2.4. Betonite properties

The solids in the bentonite fill the pores of the soil to form a weak membrane, because the density of the slurry is greater than the particle/ watersoil density, outward hydrostatic pressure forces the membrane against the sides of excavation. Thus, support is provided and the hydrostatic head in the water table is balanced.

The density of the fluid may be increased by raising the bentonite concentrations as follows.

4% by weight bentonite, will have a density of 1022 kg/m^3, is suitable in stiff clay.
10 % by weight bentonite, will have a density of 1060 kg/m^3 , is suitable in coarse soils.

2.4.1. Recycling of bentonite slurry

The bentonite slurry gets contaminated by soil particles during excavations, which if excessive, destroy its properties. However to reduce costs, for example in a long section of walling, the displaced bentonite is led into a tank and allowed to settle. The top layer is then returned to the trench. Waste slurry is usually transported to a tip in tanker trucks for disposal.

2.4.2. Application of Bentonite

Bentonite diaphragm walling is particularly suitable when combinations of both temporary and permanent support are included in the design of the structure.

1. Basement Construction
2. Pumping Chambers
3. Under ground Tanks
4. Coastal defence works and river walls
5. Retaining walls

Morrow and Posey (1983) have done two projects using graded gravel layers and bound - rock riprap for erosion protection in irrigation ditches are discussed . Rocks are bound in cylindrical wire mesh tubes in the fashion of gabbioms.

A hydraulic jump was contained with in the protected drop structure and served to dessipate erosive water velocities. Bound rock erosion proofing was also tested in an irrigation ditch below a portable canvas check dam. The graded gravel and bound rock performed well, reducing the erosion below the check dam.

Liu *et al* (1984) studied the effectiveness of stilling ponds and concrete blocks in dissipating the overflow energy of check dams.

Ciarla (1985) studied about the design and construction criteria of gabbion weirs have been used as an effective solution in many water erosion control projects and in soil stabilization and land slide control works. The functional, practical and economical characteristics of flexible gabbion weirs were described and compared to rigid structures like concrete or masonry weirs.

Nilsson and Sivanappan (1986) proposed measures and techniques for soil and water conservation and management on forest and agricultural land in Tamilnadu, which include contour bunding with stones or earth, plant bunds with catch pits, check dams, gully control structures, sand storage dams, contour trenching, stream or river training works, bench terracing, farm and percolation ponds, irrigation tanks, grassed water ways and subsurface dykes.

Visalakshi *et. al* (1986) studied about the effect of a subsurface dyke. Sufficient water was available after the construction of the dyke and used for drip irrigation in coconut field. Hardly any water was available for the irrigation at the site before the construction of subsurface dyke. It is particularly suitable in Kerala with its unique topography having hills and valleys.

Armonia and Operio (1987) have done soil and water conservation project for Salvacion village, Philippines. By mid 1986 nine field workers were employed to promote the adoption and construction of contour and drainage channels, and check dams and soil traps. The approach was successful with 22 farmers, adopted the new technology within 18 months.

Kozak *et al* (1988) studied effect of bentonite addition on soil physical properties and physical retention of Nitrate. In a field plot experiment, 100 tons of bentonite per hectre increased total water holding capacity and capillary porosity of sandy loam brown soil near Semsin. This led to an increasing water and Nitrate ritention in the top soil, following the application of 100 mm water to each plot surface and then treated with KNO3 solution.

Brito *et al* (1989) studied the construction of 3 polyethlene-lined subsurface barriers across a natural drianage line in sandy soil at Petrolina, Brazil.

Guiraud and Paepa (1989) studied the principle of using small dams, sand clay dams and subsurface dams for improving water resources and quality in Saharan and Sahelial Africa. Multiplications of these types of dams world wide would help to mitigate drought and to decrease the amount of water flowing to the oceans.

Billing and Boochs (1991) studied the use of an artificial under ground dam for an irrigation project in semi arid north- east Brazil, in field experiments and numerical simulations.

Vipulanandan *et al* (1991) evaluated field clay and clay-sand mixture when permeated and contaminated with methanol. Intraction between methnol and clay was studied using sedementation analysis and index tests. The potential of using bentonite clay as an additive in the clay-sand mixture to reduce the hydraulic conductivity of clay and clay - sand mixture could be reduced to less than 10-7 m/s by permeating with selected grout solutions or with bentonite clay additive.

Westrate *et al.*(1992) studied design aspects and permeability testing of natural clay and sand bentonite liners. A methodology has been developed to evaluate the permeability performance of natural clay and sand bentonite liners using undisturbed samples of the actual liners.

Bajwa and Narda (1993) studied silting in small checkdams used for water harvesting in the Kandy region of Punjab, India, using remote sensing.

Al-Hassoun and Al-Turbak (1995) studied the recharge dam efficiency based on subsurface flow analysis.

Leu - Chenghua *et al.*(1995) applied digital geomorphological analysis based on geographical information systems (GIS) for the selection of check dams.

Goel *et al.*(1996) studied sedement retention by gabbion structures in Bunga water shed. Eight gabbion check dams in Bunga-II catchment in Haryana, India, were evaluated. Retention capacity of each check dam at the time of construction and the reduction in capacity due to the deposition of sediment after first year and second year monsoon were studied. Results indicated that with in two years six structurers lost nearly 50 % or more of their capacity due to sediments.

Masanori (1997) studied effect of crack propagation behaviour on mechanical properties of concrete check dams.

MATERIALS AND METHODS

3.1 STUDY OF BHARATHAPUZHA BASIN

3.1.1 General

Bharathapuzha is the second longest river on the south-west coastal of India, It originates from the Anamalai Hills in the Western Ghats at an elevation of 1964m above the M.S.L and flows through Coimbatore District of Tamil Nadu and Palakkad, Malappuram and Thrissur Districts of Kerala. It finally joins in the Arabian Sea near Ponnani. The Bharathapuzha has a total length of 209 km and a total basin area 6186 sq. km of which 4400 sq. km is in the Kerala state and the remaining in Tamil Nadu. The drainage map of Bharathapuzha basin is shown in Fig 1. About 80% of the area of Palakkad district, is situated in Bharathapuzha basin.. This is approximately about 600 sq. km.

The main tributaries of Bharathapuzha are:

1. Gayathripuzha
2. Chitturpuzha(Kannadi or Amaravathi)
3. Kalpathipuzha and
4. Thuthapuzha

3.1.2. Water resources potential of bharathapuzha

3.1.2.1 Hydrological Features Of The Basin

The available data on rainfall, flow evaporation and various hydro features have been considered in estimating the available water resources of Bharathapuzha basin. The Bharathapuzha basin experiences two distinct monsoon namely South west monsoon(June-August) and the north west monsoon (September-November). These two monsoon accounts for about 60% of the annual rainfall. The average annual rainfall in the state is about 3085mm whereas the same for the basin is estimated to be 2500 mm.

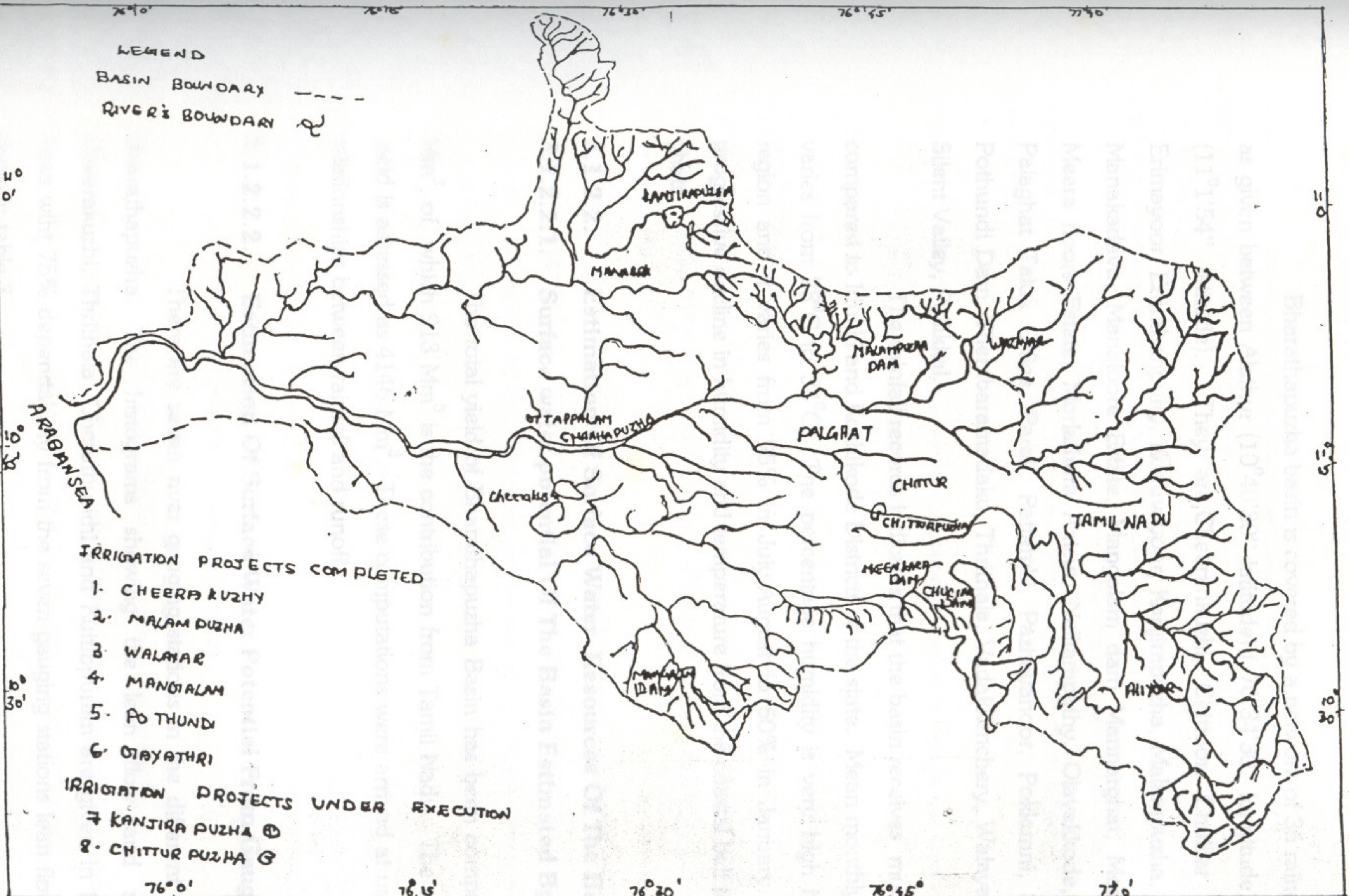


Fig. 1. Drainage map of Bharathapuzha basin .

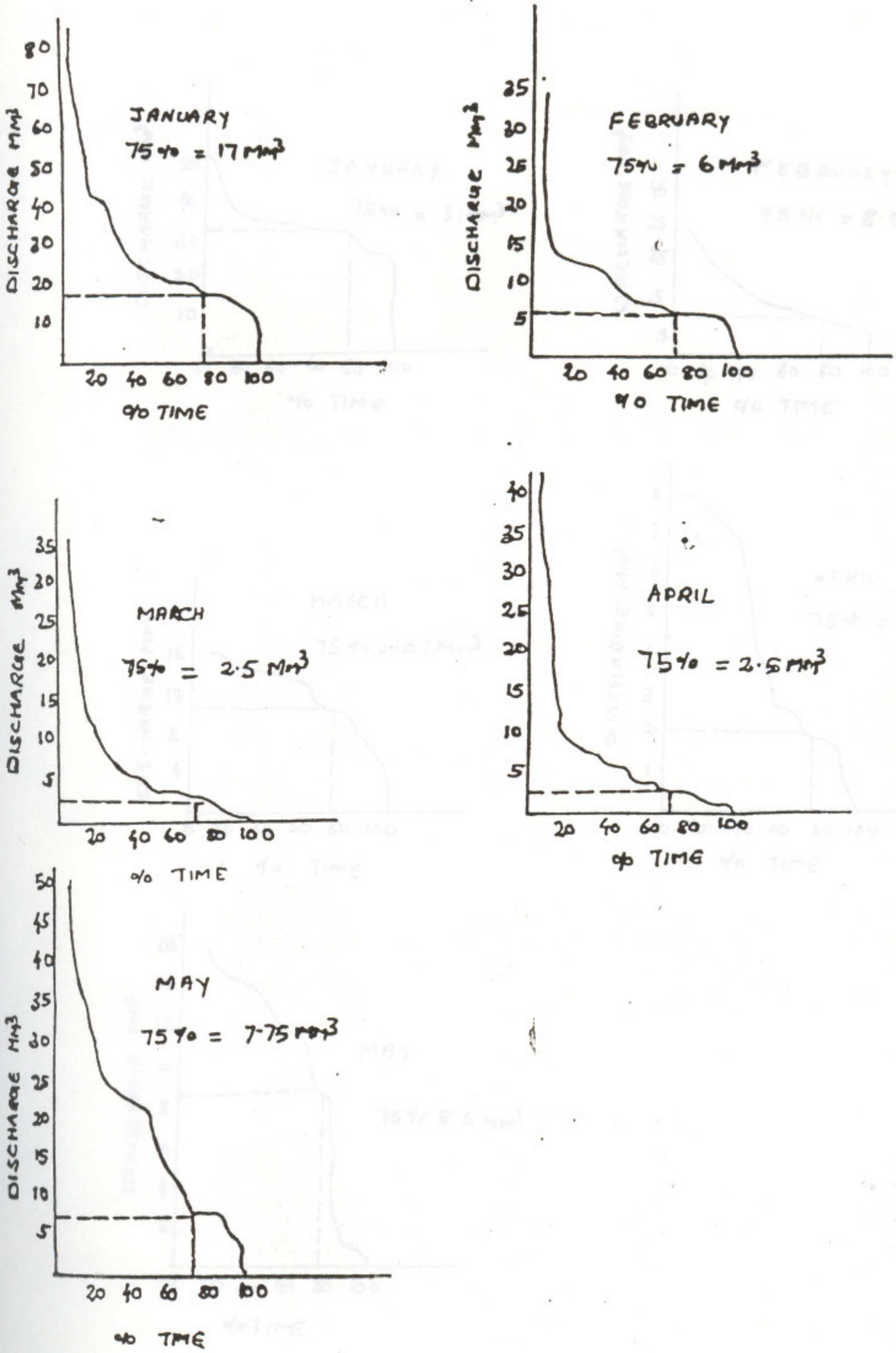


Fig. 2. Flow duration curve of Pampady station

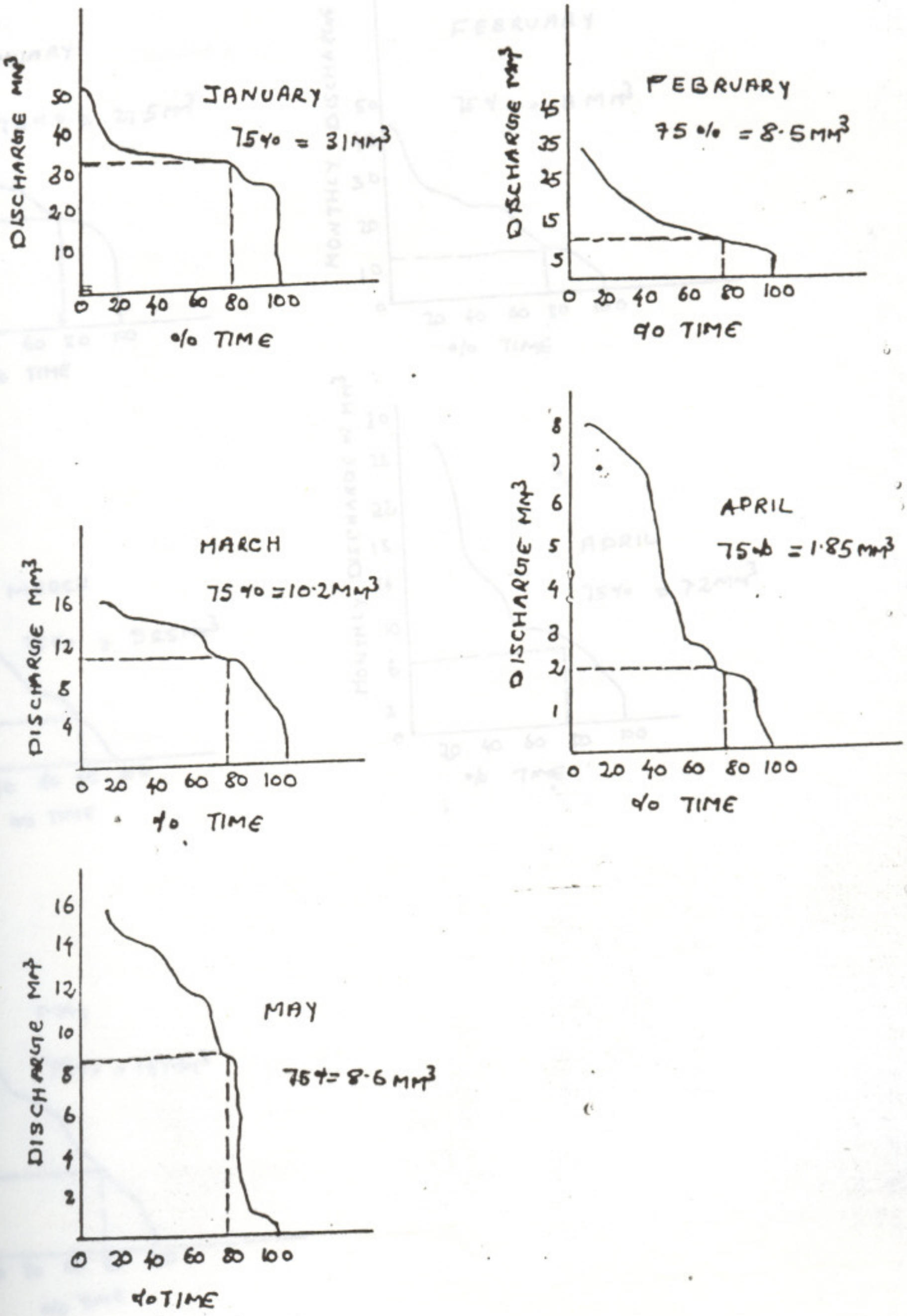


Fig. 3. Flow duration curve of Manakadavu station.

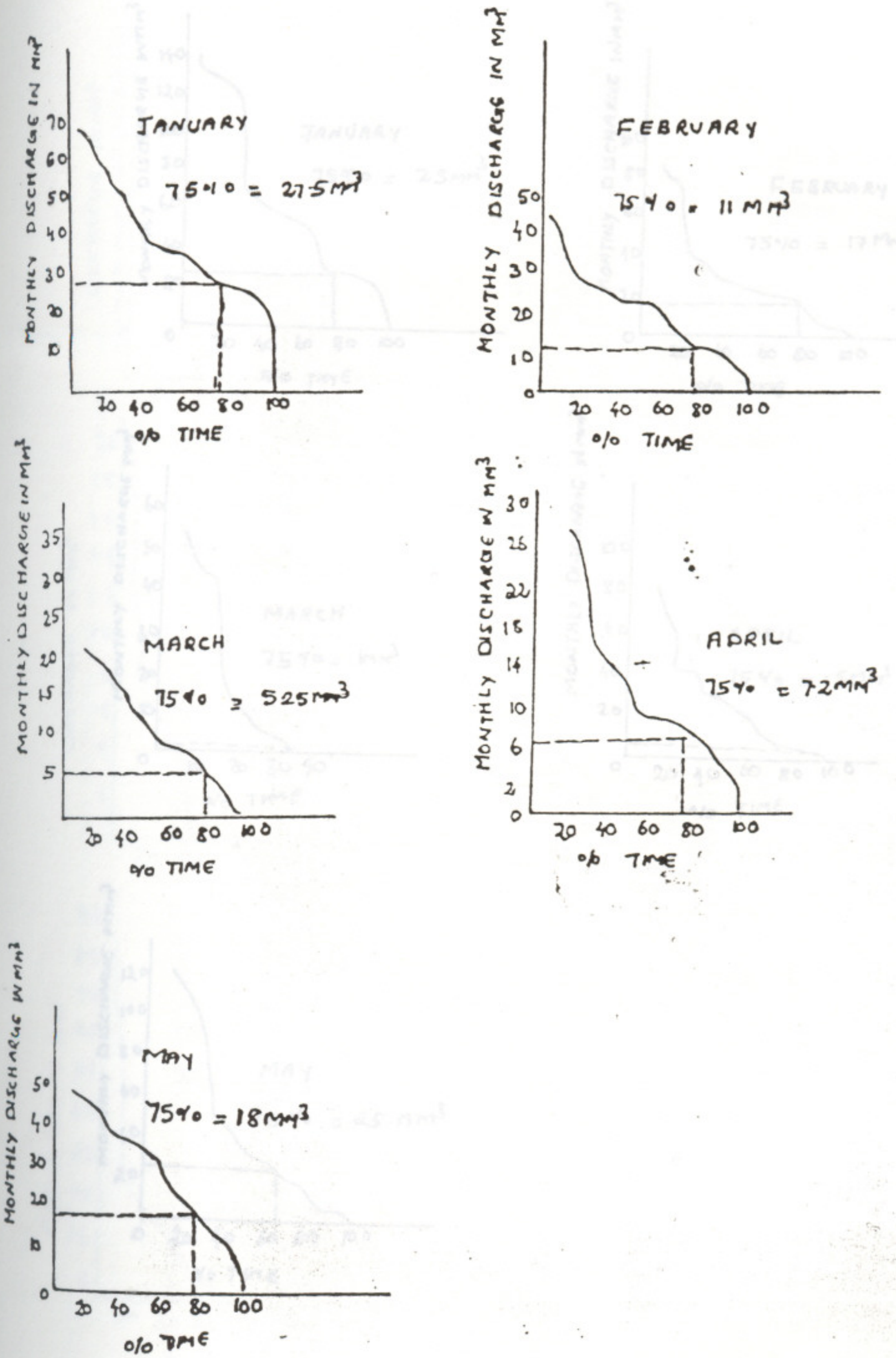


Fig. 4. Flow duration curve of Cheruthuruthi station.

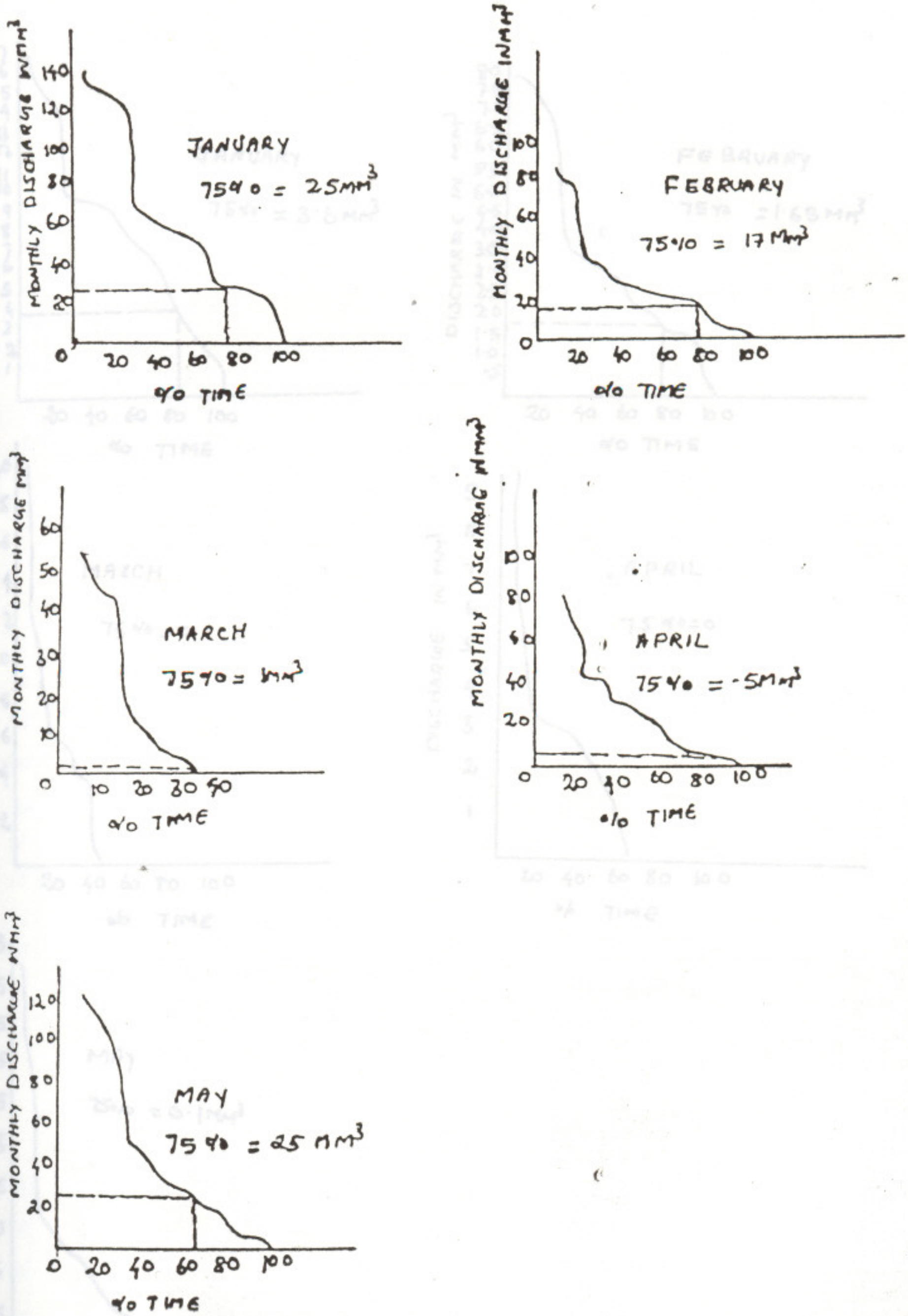


Fig. 5. Flow duration curve of Kuttippuram station.

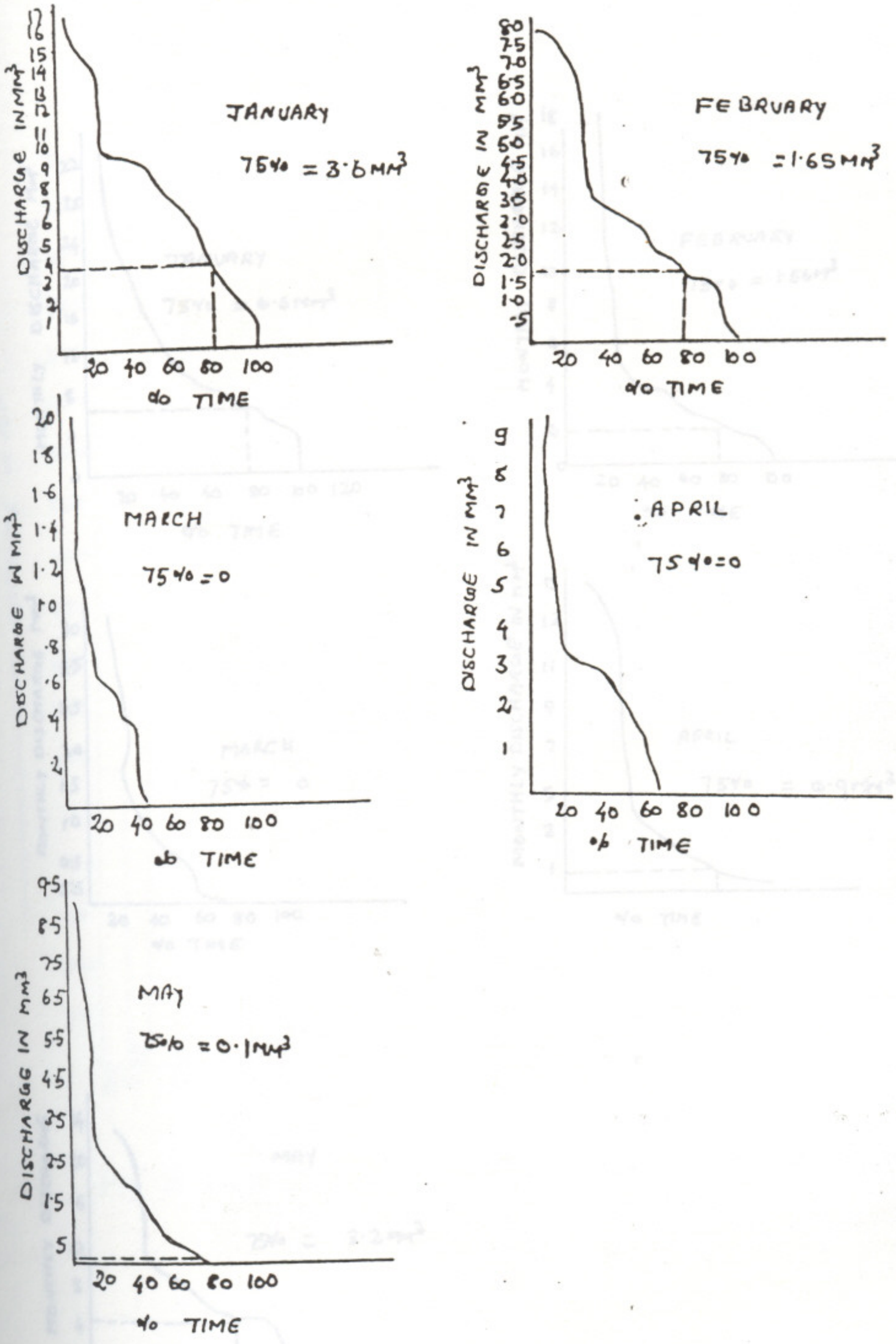


Fig. 6. Flow duration curve of Cheerakuzhi station.

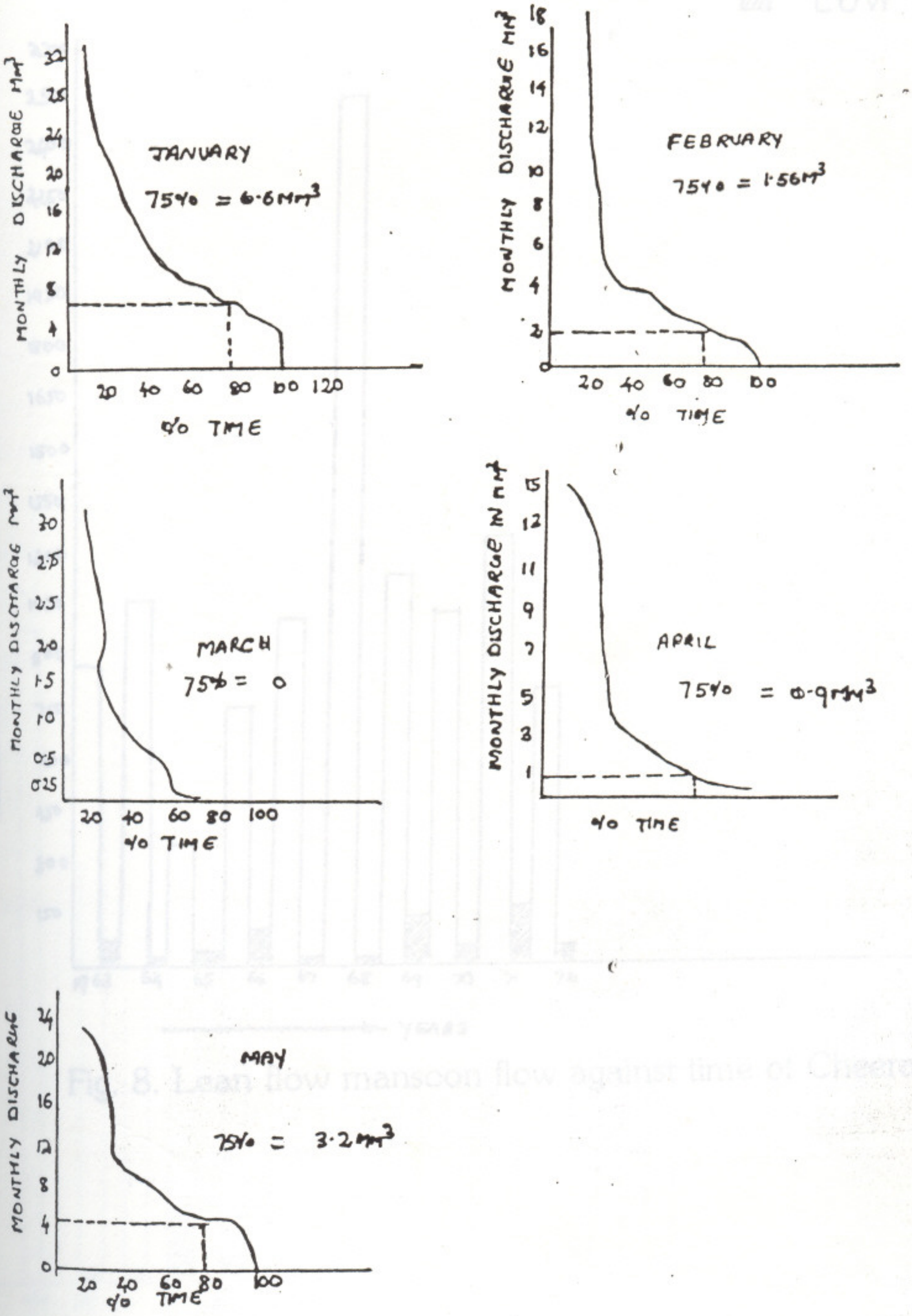


Fig. 7. Flow duration curve of Thiruvengapuram station.

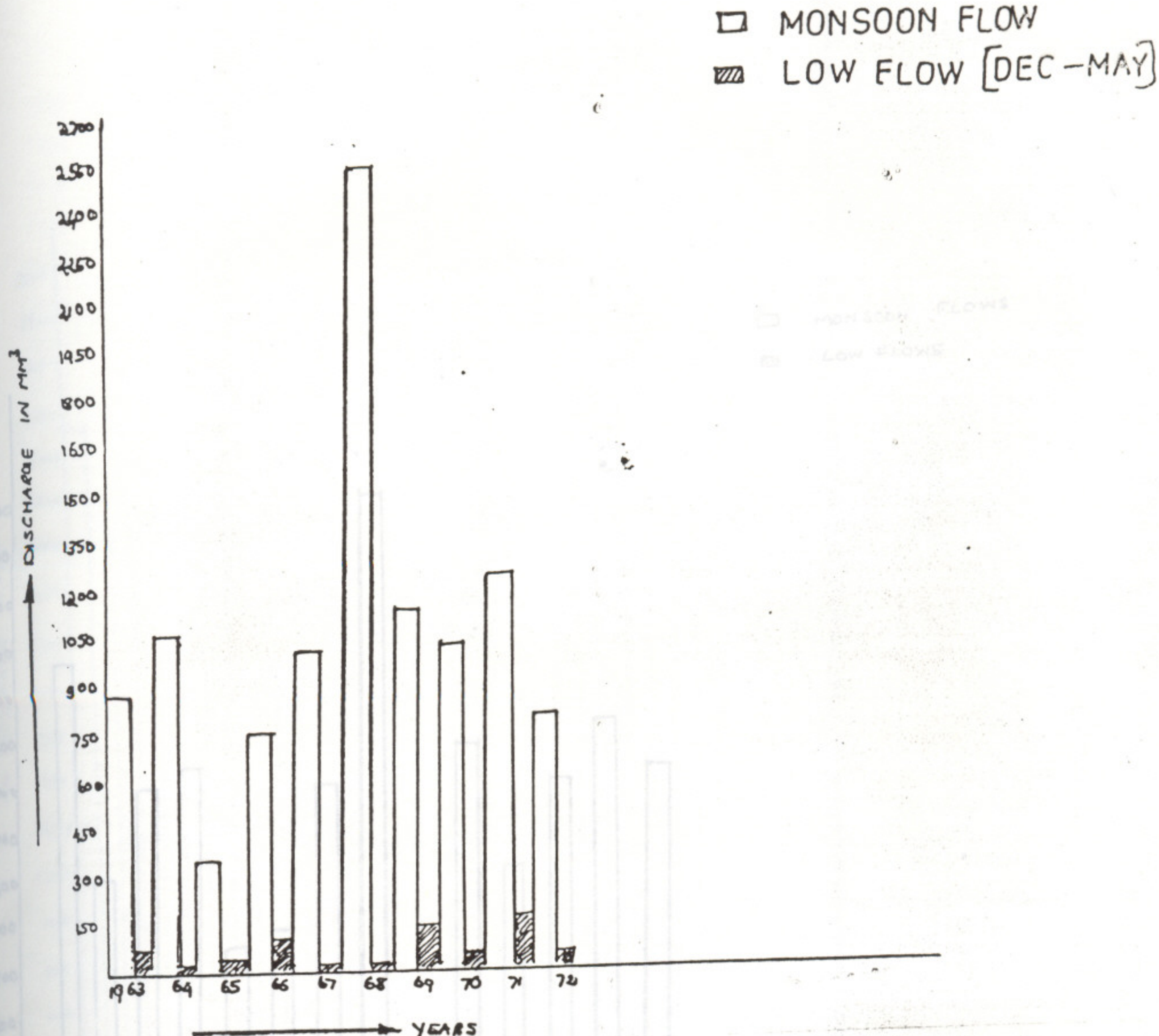


Fig. 8. Lean flow mansoon flow against time of Cheerakuzhi weir.

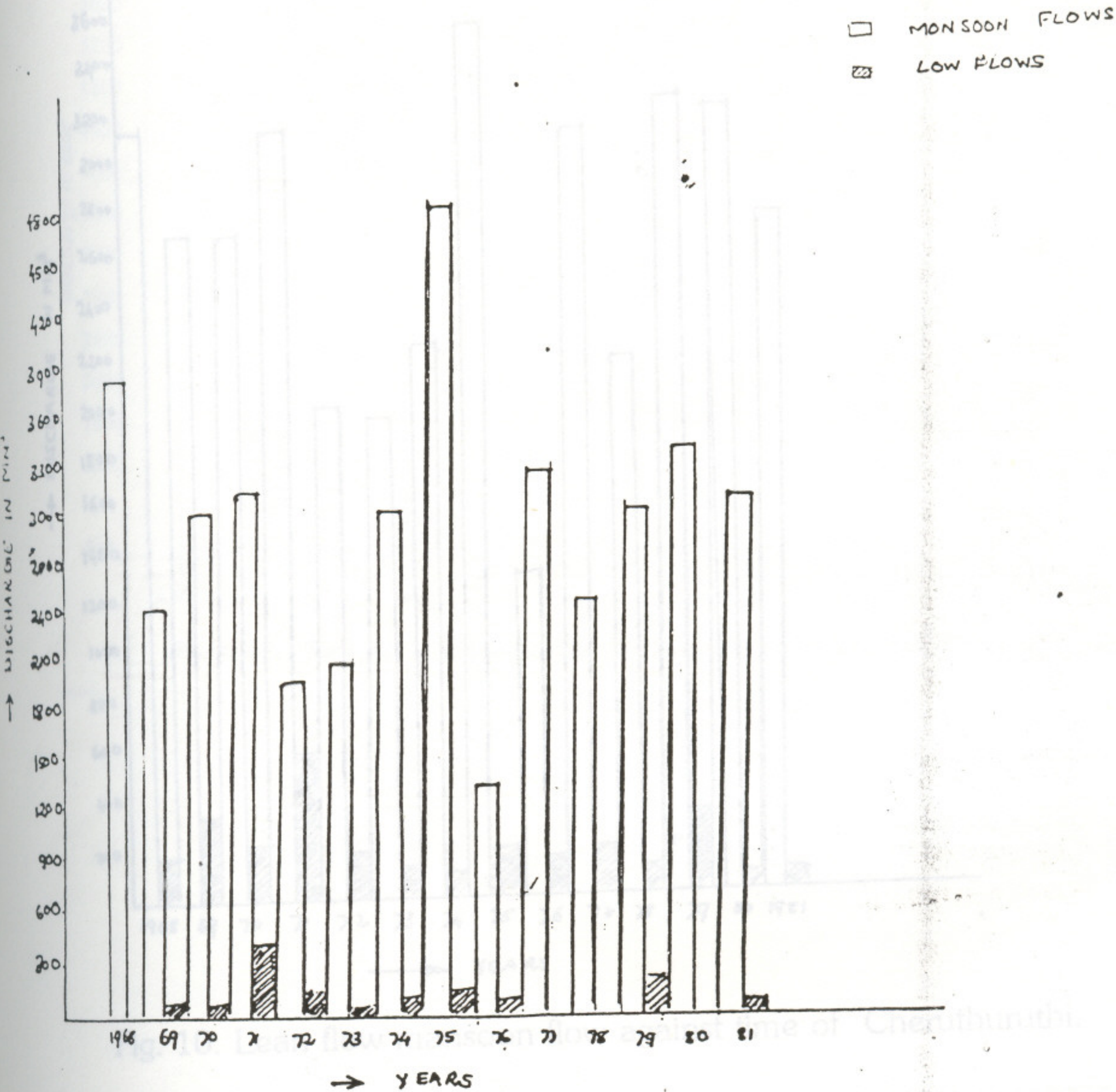


Fig. 9. Lean flow mansoon flow against time of Thrithala.

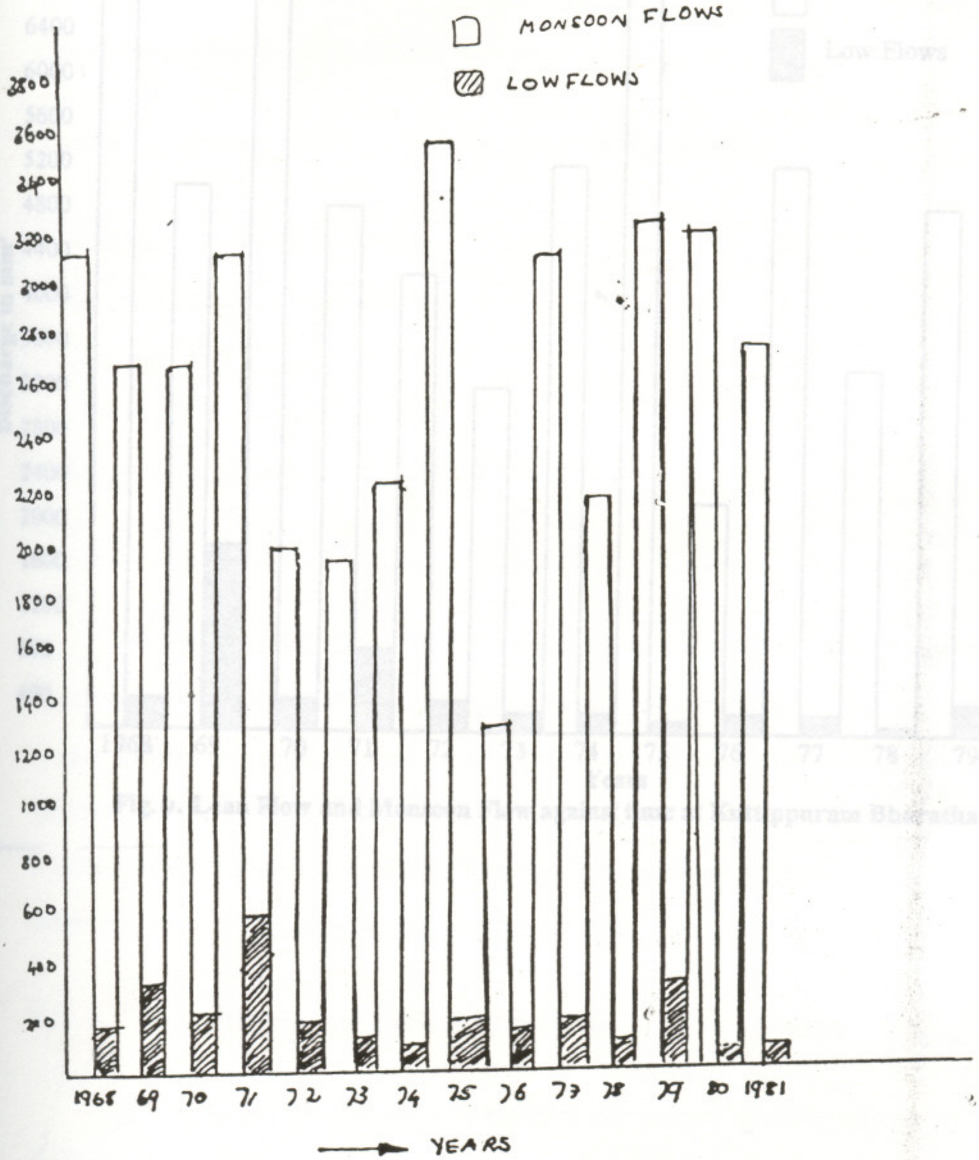


Fig. 10. Lean flow mansoon flow against time of Cheruthuruthi.

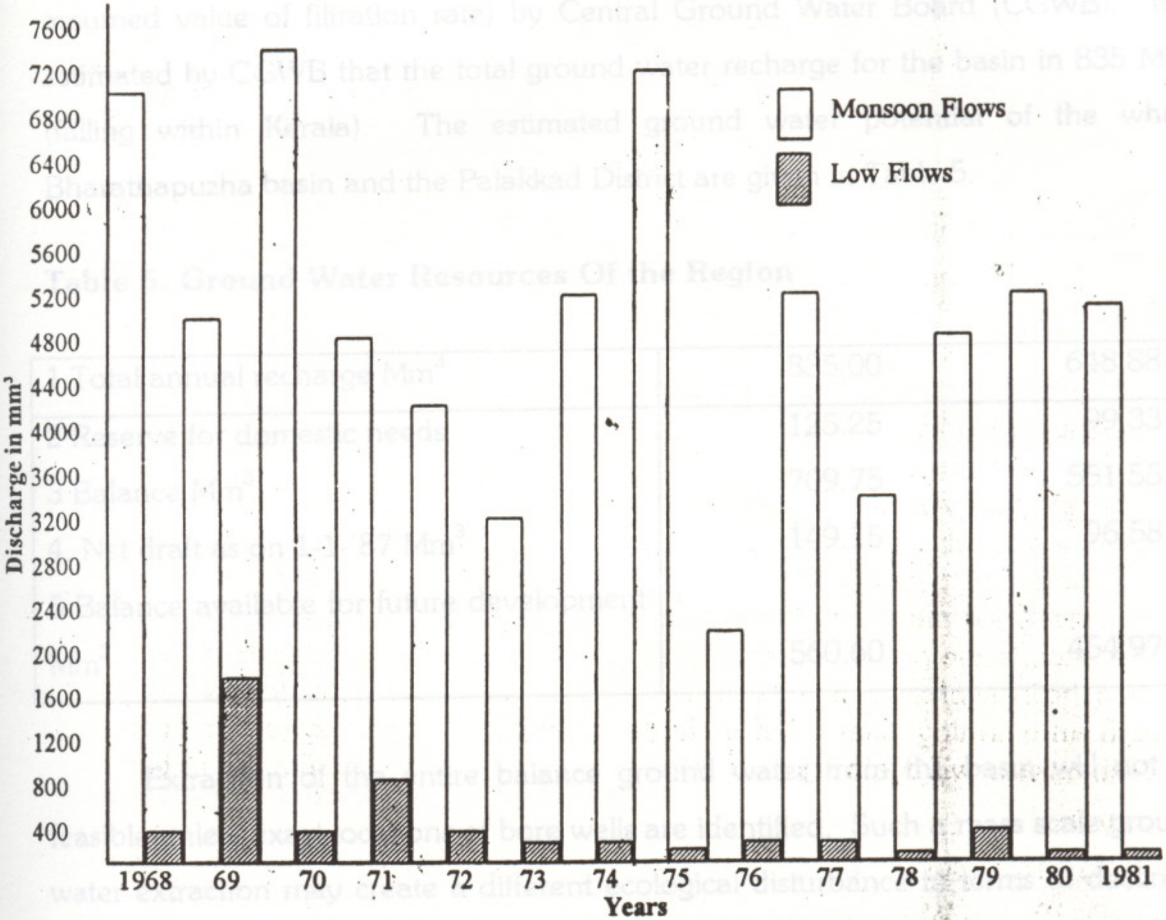
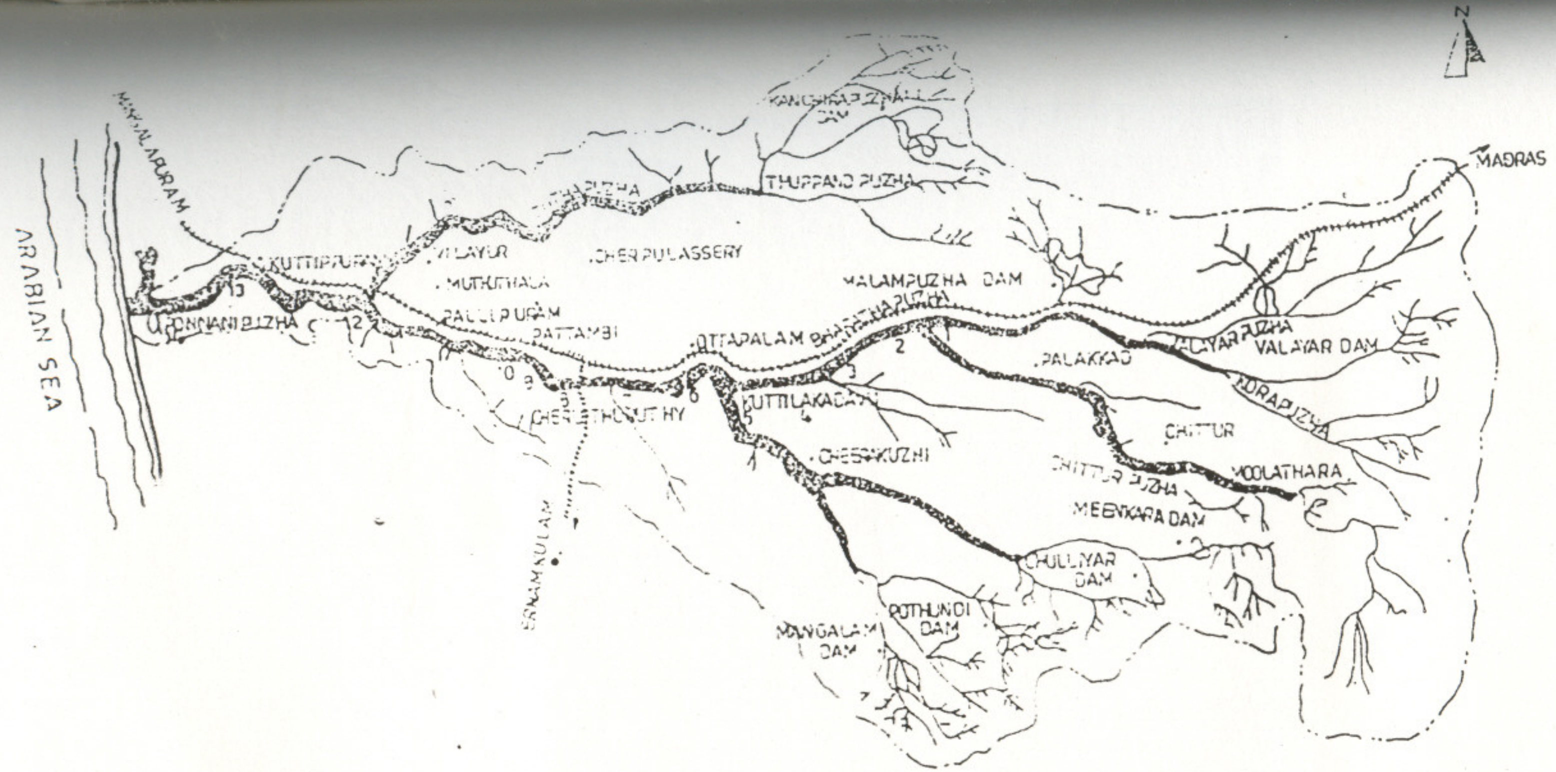


Fig. 11. Lean Flow and Monsoon Flow against time at Kuttippuram Bharathapuzha Basin



1. PARALI OLD BRIDGE
2. PARALI OLD RAILWAY STATION
3. NJAVALIN KADAVU
4. LAKKIDI
5. PALAPPURAM KOOTTILAMUKKU
6. OTTAPALAM
7. THRANGALI
8. MUNDAYA-SHORANUR
9. KONDAYOOR-KARAKKAD
10. PATTAMBI
11. VELLIYAMKALLU REGULATOR CUM BRIDGE
12. PALLIPURAM KOOTTAKADAVU
13. THIRUNAVAYA
14. CHAMMRAVATTOM REGULATOR CUM BRIDGE

Fig. 12. Locations for construction of checkdams / sub-surface dams in Bharathapuzha.

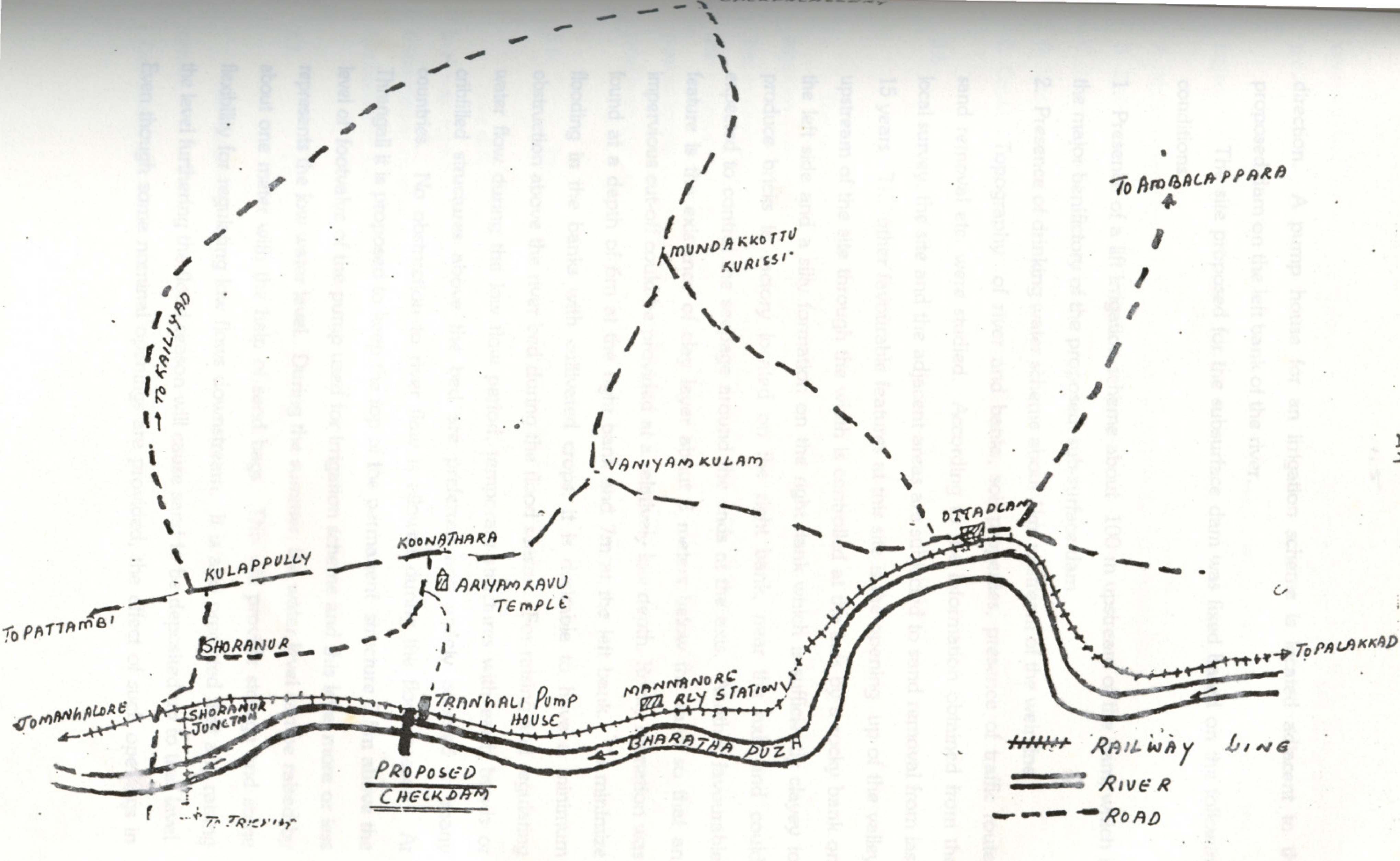
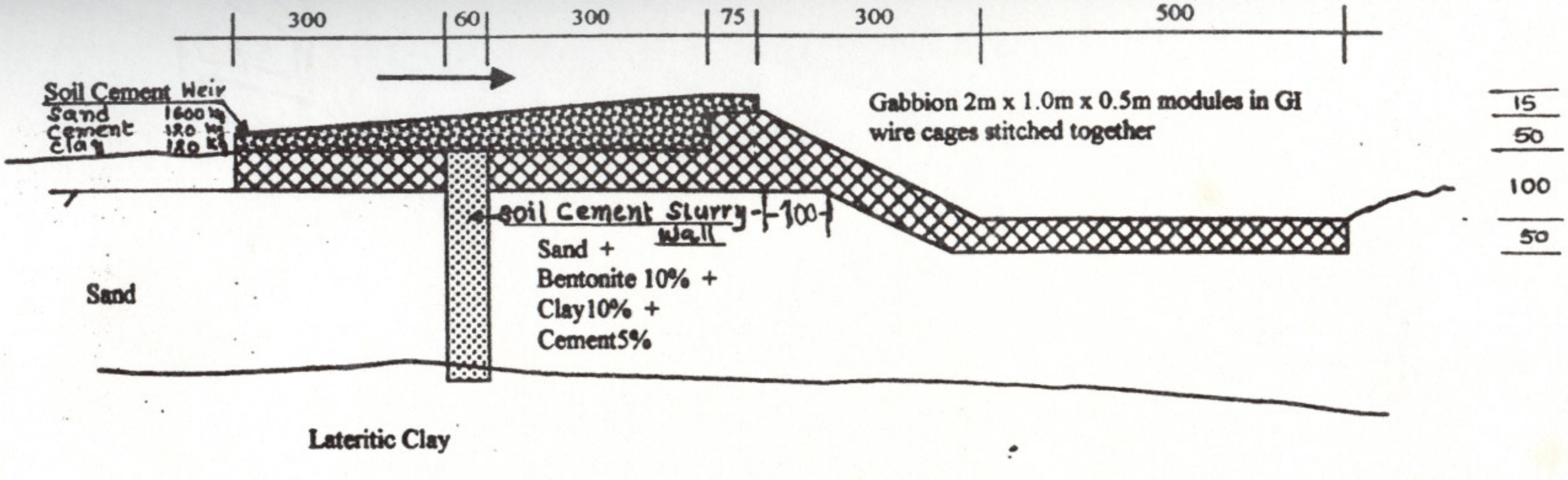


Fig. 13. Construction of check dam across bharathapuzha at Thrangali Kadavu in Vaniyam kulam Panachayath, site plan.



ALL DIMENSIONS IN CM

Fig.14 CROSS SECTION OF SUB-SURFACE CHECK DAM ACROSS RIVER BHARATHAPUZHA

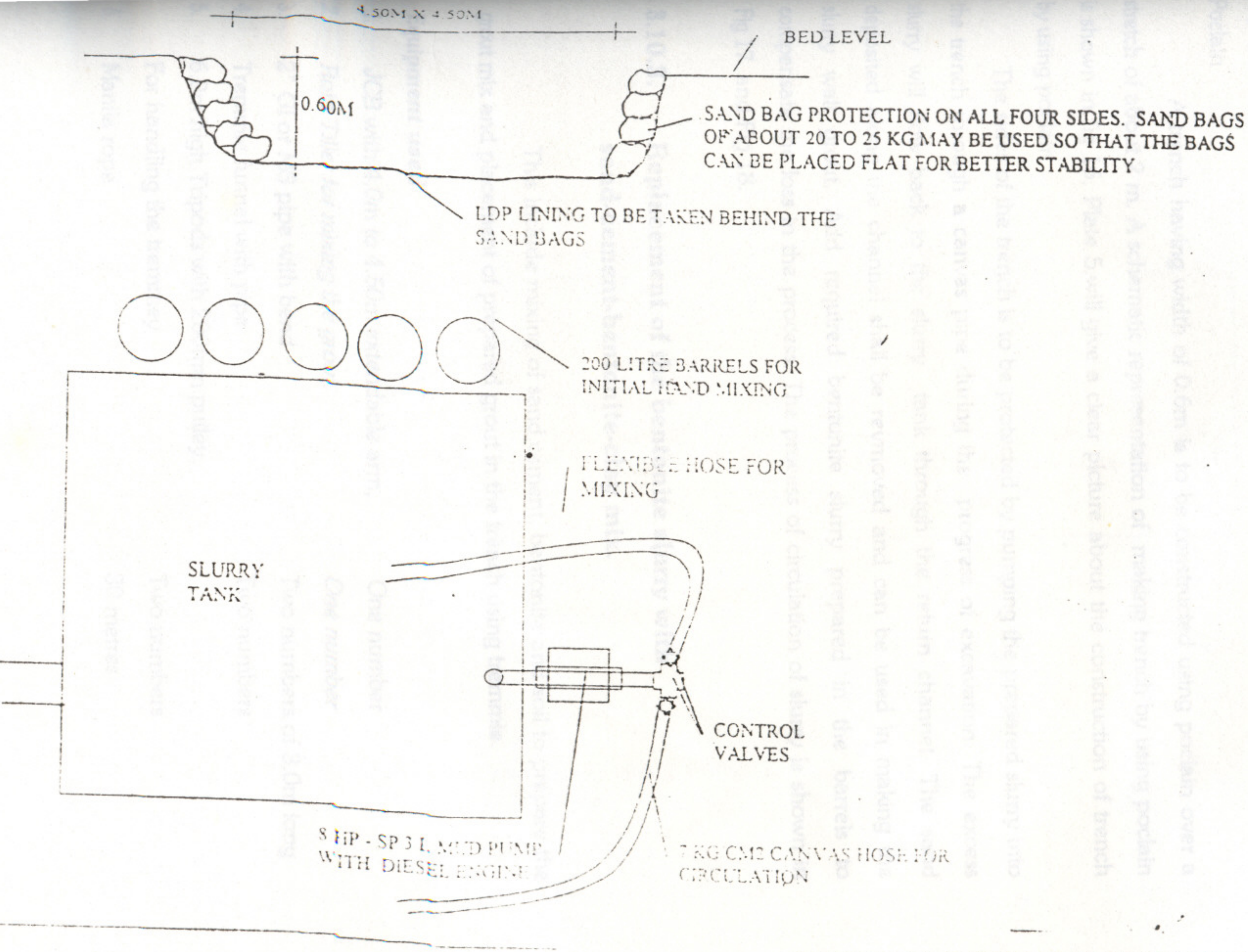


Fig. 15. Schematic diagram of slurry tank.

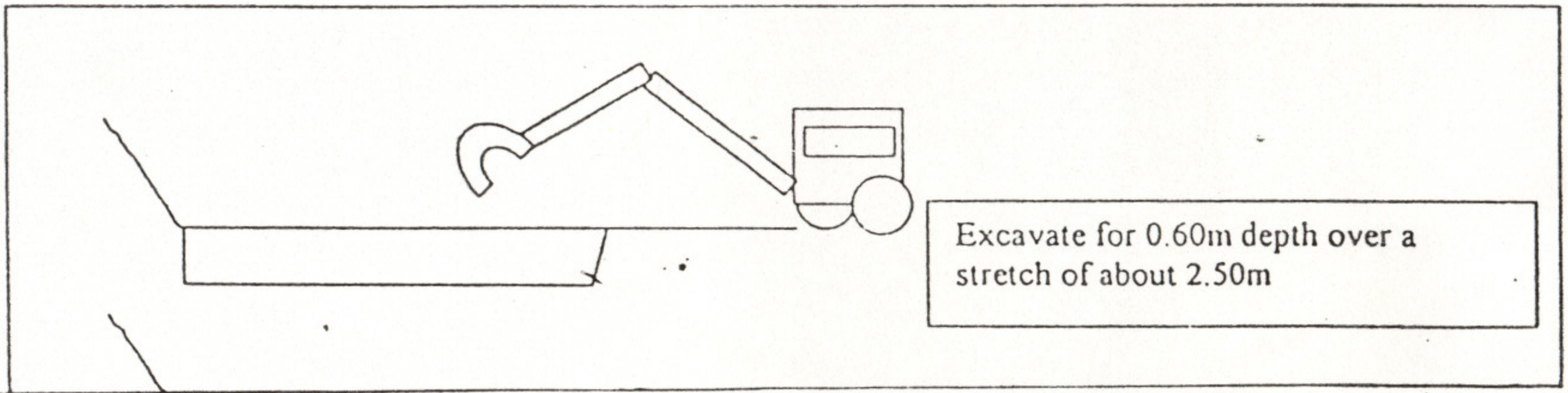


Fig. 16. Making of trench by using Poclain.

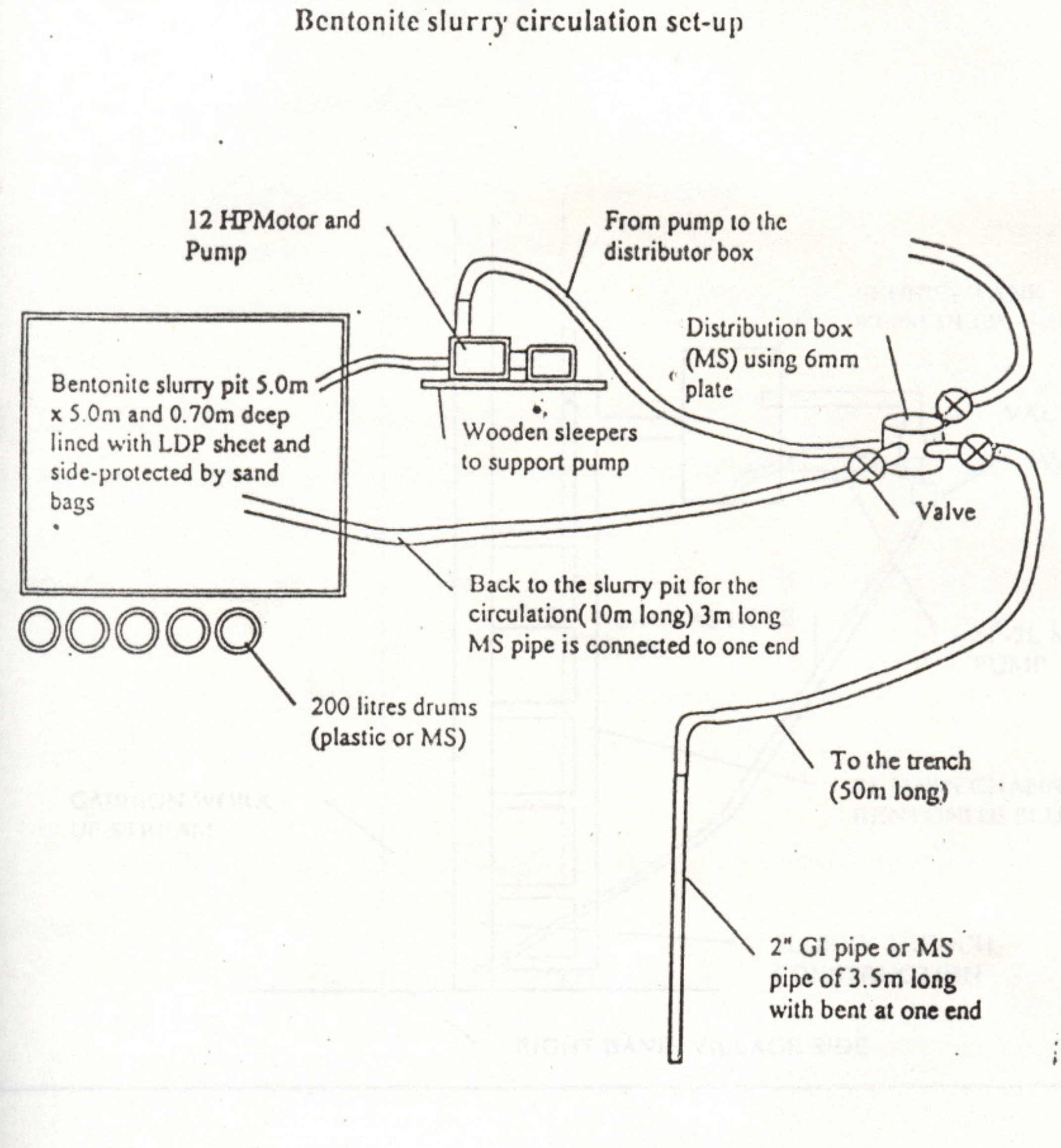


Fig. 17. Process of circulation of slurry from slurry tank.

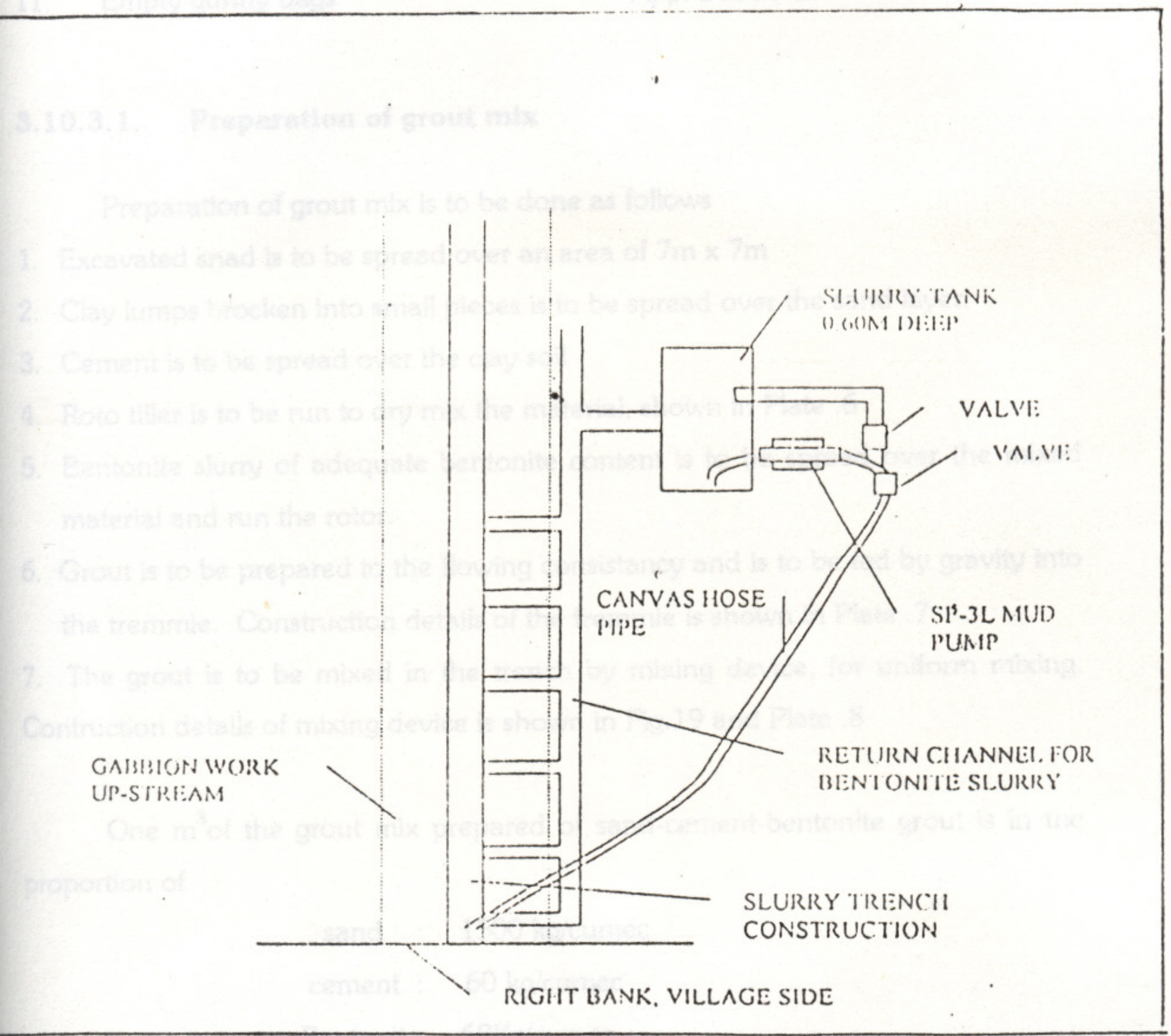


Fig. 18. Process of circulation of slurry into the trench.

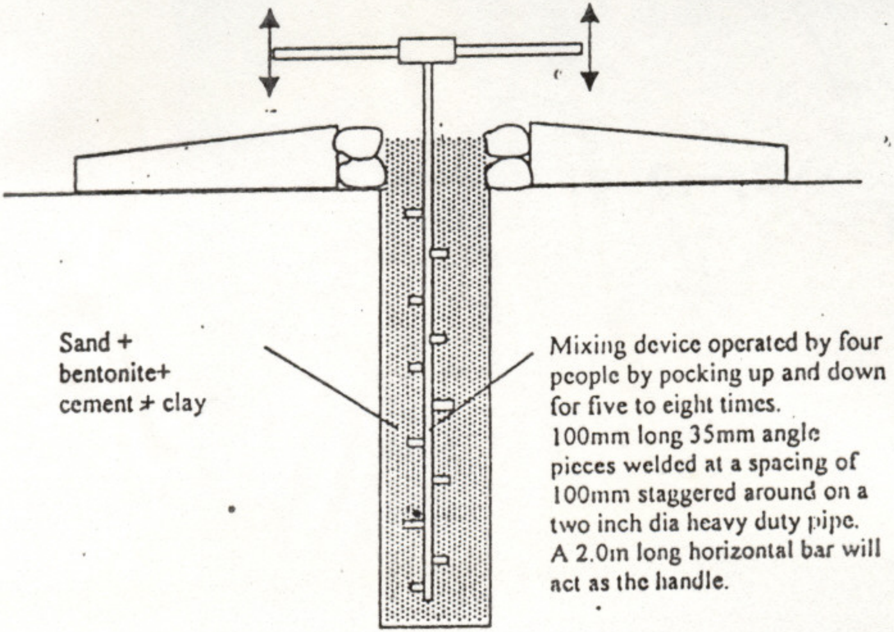


Fig. 19. Construction details of mixing device.

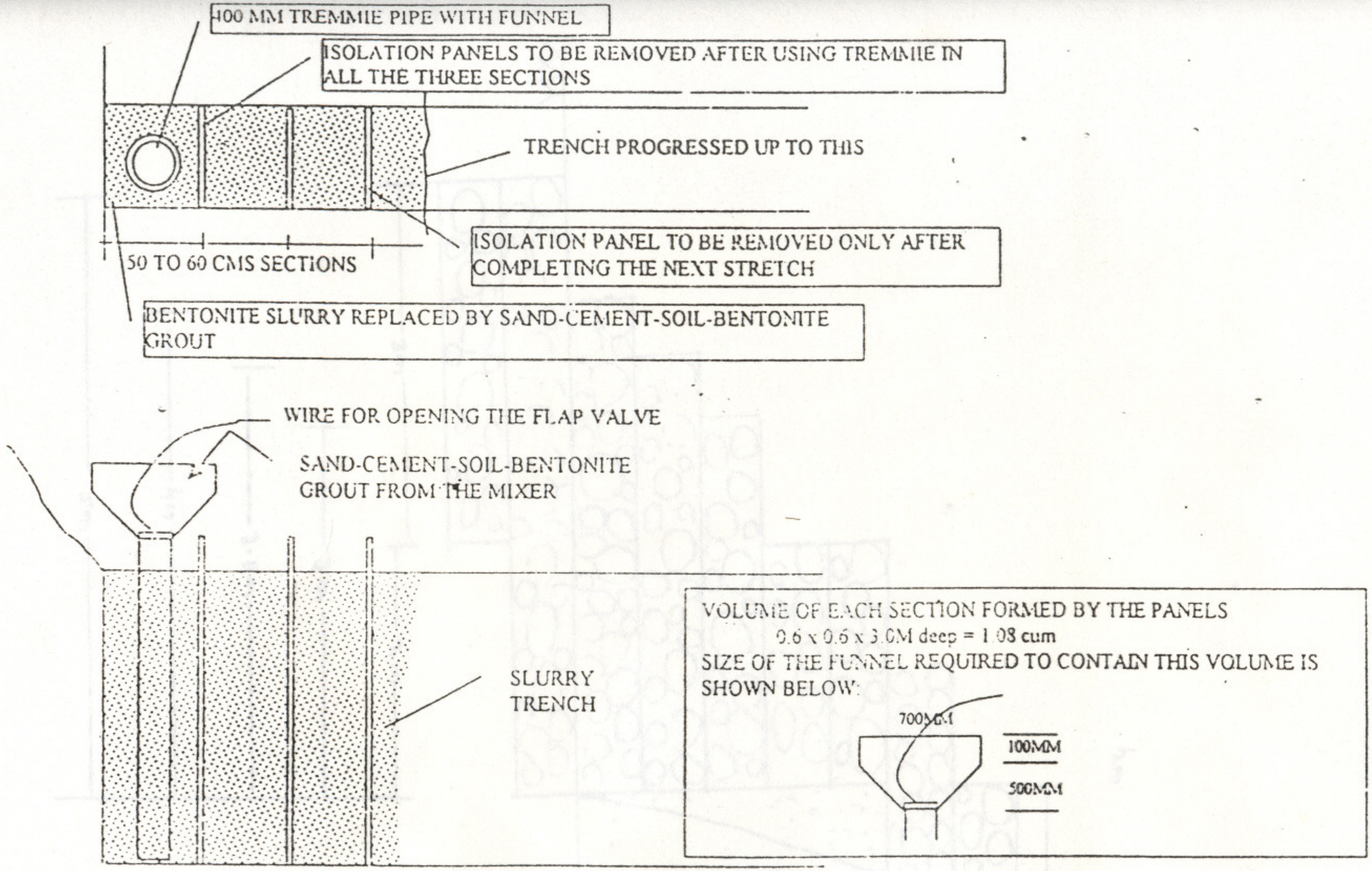


Fig. 20. Circulation of grout mix.

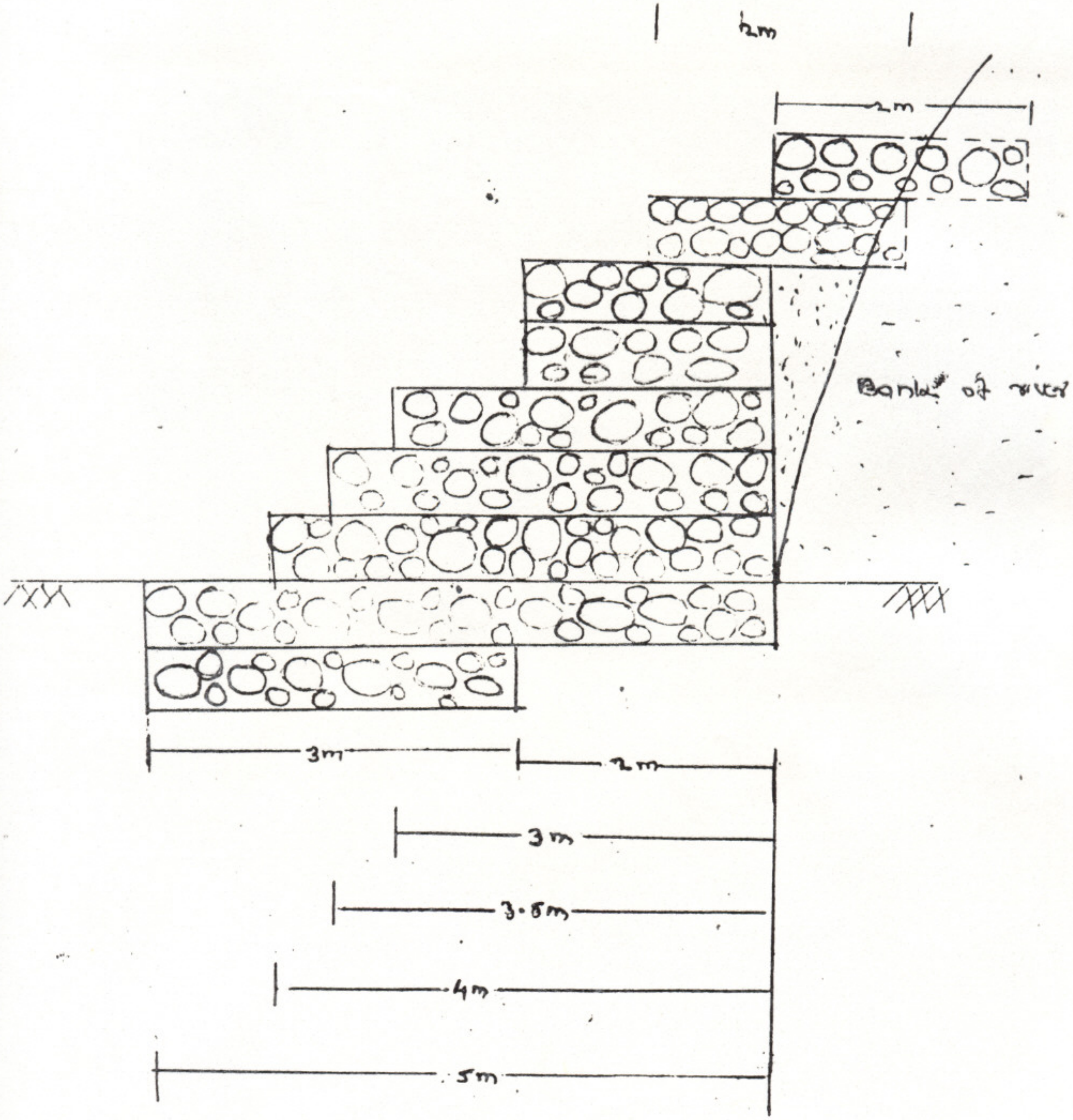


Fig. 21. Construction details of side protection works.

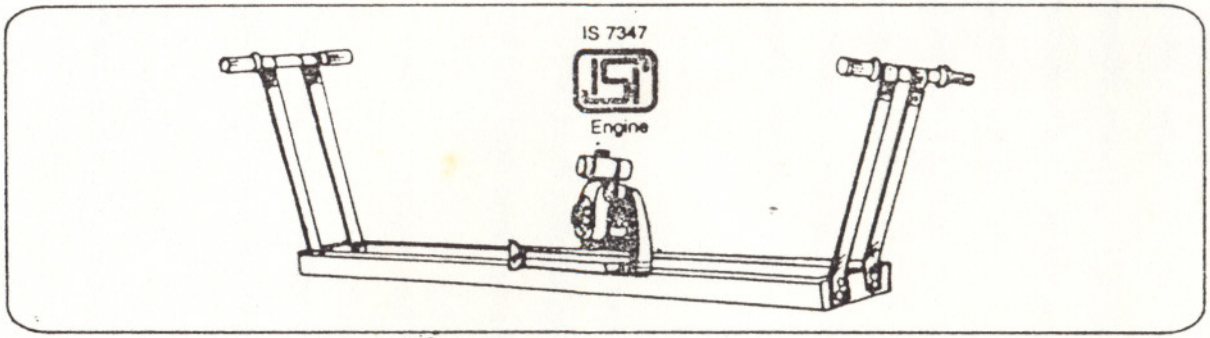


Fig. 22. Vibratory plate compactor.

Bharathapuzha basin is covered by a network of 36 raingauge stations as given between Alathur ($10^{0}40'30''$ latitude),($76^{0}34'30''$ longitude) and Pulickal ($11^{0}1'54''$ latitude). They are,Cheerankuzhi, Chittoor, Chulliar dam, Elanal, Erimayoor, Eranthanputty, Koduvayoor, Kanjirapuzha, Malampuzha, Malliserikavu, Manakadavu, Manaloore Estate, Mangalam dam Mannarghat, Meenakara dam, Meera floors Estate, Morlathara Anicut, Nelliampathy, Olavakkode, Ottappalam, Palaghat Taluk Office, Parali, Pattambi, Pazhayanoor, Pokkunni, Shornur R.S, Pothundi Dam, Thembaramadaku, Thrithala, Vadakkenchery, Walayar, Ponamani, Silent Valley, Pullikkal.

The rainfall records indicates that the basin receives much less rainfall compared to Idukki and Kozhikode Districts of the state. Mean monthly temperature varies from 28^{0}C to 34^{0}C. The percentage humidity is very high in the coastal region and it varies from 95% in July-August to 60% in January. There is a progressive decline in humidity and temperature from the coastal belt to the western ghats.

3.1.2.2. Estimation Of Surface Water Resources Of The Basin

3.1.2.2.1. Surface water potential Of The Basin Estimated By P.W.D

The total yield of Bharathapuzha Basin has been computed as 7478 Mm^3, of which 913 Mm^3 is the contribution from Tamil Nadu. The total utilizable yield is assessed as 4146 Mm^3. (These computations were arrived at using empirical relationships between rainfall and runoff.)

3.1.2.2.2. Estimation Of Surface Water Potential From Gauged Data

There are seven river gauging stations in the different tributaries of Bharathapuzha. The histograms showing the lean flow and monsoon at Cheerakuzhi, Thrithala, Cheruthurithi and Kuttippuram are given in figures. The flows wiht 75% dependability from the seven gauging stations lean flow period are given in table 3.

Based on the actual observations and experience, it is estimated that only 85% of the flow in the highlands, 50% of the flow in the mid land 0% of the flow in the low land are utilizable. Therefore, the flow at different gauging stations will have utilizable yield less than what is observed.

Surface water potential of the Basin with the details such as livestorage of reservoirs in the basin and water available from adjacent basins are given in table 4.

3.1.3. Water resources created through major, medium and minor irrigation schemes

The are six major or medium irrigation projects commissioned in the basin with total live storage of 339.4 Mm^3 and with a command area of 38648 hectares. In addition, there is a diversion scheme with a command area of 1620 hectares within the basin. Apart from the irrigation reservoirs, there is no large scale storage facility in the basin.

The 75% dependable flow (annual) at Kuttippuram, situated downstream of the river is computed as 4690 Mm^3. This include the flow from the unitercepted catchments, spill over from the reserviors and return flows. Some amount of water is lost due to extraction for public and private uses from upstream.

As is evident from the flow duration curves (shown in figure.2 to figure.11), for most of the development activities such as irrigation and water supply schemes, surface water flow may have to be used in conjunction with subsurface flows especially during the lean flow periods.

3.1.4 Water diverted from adjacent basin

In addition to the water available from within the Bharathapuzha basin 71 Mm^3 of water is already available from Parambukulam - Aliyar Project primarily for irrigation purpose in the Chittor Taluk of Bharathapuzha basin. According to Kerala - Tamil Nadu agreement 71 Mm^3 of water from the Bhavani basin (Siruvani) is also available for irrigating Attapadi velley lands of Palakkad district.

Table 3. 75% dependable flow at different gauging sites during lean flow period

Month	Kuttippuram	Thiruvega	Cheruth-uruthi	Manaka - davu	Cheerk - uzhi	Pam - pady
January	25.00	6.60	2.75	31.00	3.60	17.00
February	17.00	1.56	11.00	8.50	1.65	6.00
March	1.00	0.00	5.25	10.20	0.00	2.50
April	5.00	0.90	7.20	1.85	0.00	2.50
May	25.00	5.20	18.00	8.60	0.10	7.75

Table 4. Surface water potential of the basin with details of utilization

Parameters	Quantity Mm^3	Source
Total Yield	7478	P.W.D., 1974
Contribution of Kerala Catchments	6540	-do-
Contribution of Tamil Nadu Catchments	938	-do-
Total utilizable yield in Kerala	3349	-do-
Total utilizable yield in Tamil Nadu	797	-do-
Yield at Kuttippuram (downstream poinnt)	4690	CWRDW, 1983
Live storage in irrigation reserviors	339.4	P.W.D., 1974
Diversion from Parambikulam - Aliyar Project	71.0	Intersate agreement

3.1.5 Ground water resources

The ground water recharge for the Bharathapuzha basin was computed (based on the fluctuation in the ground water level a few observation wells and an assumed value of filtration rate) by Central Ground Water Board (CGWB). It is estimated by CGWB that the total ground water recharge for the basin in 835 Mm^3 (falling within Kerala). The estimated ground water potential of the whole Bharathapuzha basin and the Palakkad District are given in Table 5.

Table 5. Ground Water Resources Of the Region

1 Total annual recharge Mm^3	835.00	648.88
2 Reserve for domestic needs	125.25	99.33
3 Balance Mm^3	709.75	551.55
4. Net draft as on 1-1-'87 Mm^3	149.15	96.58
5 Balance available for future development Mm^3	560.60	454.97

Extraction of the entire balance ground water from the basin will not be feasible unless exact locations of bore wells are identified. Such a mass scale ground water extraction may create a different ecological disturbance in terms of declining ground water table. This declining ground water table requires higher energy input to the energy already stored in the basin as well as it may encourage salinity ingress from the sea in the coastal belt of the basin.

3.1.6. Minor irrigation schemes

In addition to the area irrigated by major and medium irrigation projects 5480 hectares (net) is irrigated by minor irrigation schemes. The minor irrigation schemes include:

1. Reclamation of small swampy areas making them fit for cultivation by bunding and dewatering when required.
2. Improving the existing irrigation tanks and pumping water to the field.

3. Storing of flood and rainwater in small reserviors and tanks and utilizing the same for raising crops during non-rainy season.
4. Salt water exclusion works in the coastal region.
5. Drainage works intended to protect the paddy fields from the damage of flood.
6. Divisions of structures put up across which do not dry up during irrigation seasons with a view to divert the streams flow into the fields, and
7. Lift irrigation schemes by the sides of rivers.

3.1.7. Utilization for drinking water

The details of existing drinking water supply schemes and future needs in different villages/taluks of Palakkad district (furnished by KWA) are given in table 6. Table gives the present schemes and future needs of municipal areas in the Palakkad district.

As inferred from the tables the drinking water supply schemes of Palakkad district cater to a population 5,93,100 in rural areas. The annual utilization at 40 1pcd work out 8.67 Mm^3

3.1.8. Utilization for hydel power

Presently there is no hydel power stations in the Bharathapuzha basin. The Silent Valley Project proposed earlier was given up due to environmental considerations. The energy and power requirements of the basin can be economically met from the adjacent basins of Chalakudy and Bhavani which have high Hydel potential

3.1.9. Utilization for other purposes

3.1.9.1. Inland navigation

In the lower reaches about 40km of Bharathapuzha and 9.6km of Tirurpuzha are navigable. This system of communication was made possible by constructing artificial canals interlinking lagoons, backwaters and the mouths of river provide a continuous water way from Hosdurg to Trivandrum. The improvement of certain stretches of the artificial canals in the lower reaches of Bharathapuzha include future works like linking Ponnani with Chetuvai are under consideration.

3.1.9.2. Fisheries

The fresh water reservoirs of Bharathapuzha basins are being utilised for pisciculture. A few water biological research station has been established at Malampuzha. The research station also distributes good quality fingerlines to the public. About 30 lakh fingerlines are raised annually from the reservoirs situated in the Bharathapuzha basin.

3.1.9.3. Water Sports And Tourism

The Malampuzha reservoir is one of the leading tourist centres developed in the state. The swimming pool, fishbreeding centre, garden, mini zoo, childern's park, boating facilities and good accommodation attract tourist to the malampuzha which is close to the Palakkad Town.

3.1.10. Future requirements of water in the region

3.1.10.1 Requirements In The Irrigation Sector

The utilisable surface water, yield in the basin is 3349Mm^3 and ultimate requirement will be available for irrigation is 4684Mm^3. In addition 142Mm^3 will be available as per the existing interstate agreement. Therefore to meet ultimate irrigation requirements of the basin, there is a deficit of 193 Mm^3 of water, which has to be met by ground water utilization and diversion from adjacent basin.

With the background of total water available in the basin and the total area to be irrigated, an attempt has been made to ascertain the spatial and temporal requirements of water for irrigation. The area as such depends on pre monsoon and monsoon showers for the first crops (viripu), a steady supply of water required to succefully raise the second crop (mundakkan) in which generally transplantation is done instead of broadcasting as the first crop; for the third crop(puncha) assured irrigation is essential. The crops do not require irrigation water generally from June to October. Frequency analysis of rainfall data of Palakkad has shown that the average number of rainy days is 127.

3.1.10.2. Requirements In The Domestic Sector

The drinking water requirements of different villages, municipalities and Taluks of Palakkad district are estimated The study also gives the present utilization and the resources which is shown in table 6.

By 2020 A.D, the additional requirements for rural population at 40 1pcd works out to 46Mm^3 and for urban population at 140 1pcd works out to 12Mm^3.

3.1.10.3. Requirements In The Industrial Sector

The industrial water requirements till 2000 A. D in the district are found out to be about 13 Mm^3. However theses figures were arrived at by K.W.A considering only the existing major industrial units and the proposed ones.

3.10.4. Requirements For Salinity Exclusion And Other Purposes

On the basis of certain model studies conducted and the regionalisation carried out at KERI, (Peechi) it is estimated that atleast 44m^3/second discharge has to be maintained to arrest salinity in Bharathapuzha and Tirur basins. The total quantity of water required therefore works out to 686 Mm^3 for both the basins to bring down the salinity to reasonable limits during the six summer months.

Other development activities such as inland navigation does not require any special conservation or management strategies with the development of Ponnani port. The requirement of water for drinking purposes would be 0.2Mm^3.

3.1.11. PROPOSALS FOR MEETING WATER DEFICIT IN THE REGION

3.1.11.1. Irrigation

Considering the future demands and possible sources of water, the following proposals were made to partially cater to the ultimate irrigation needs of Palakkad district in particular and Bharathapuzha basin in general.

(1) Construction of structures-Specific structures like Check dam, weirs and lift irrigation units were proposed to conserve available stream flow. Construction of infiltration gallery is necessary to use subsurface flow.

(2) Adopting effective irrigation water management practices by utilizing the water available from existing irrigation projects, and diversion water available from Parambikulam Aliyar And Siruvani.

(3) Execution of minor irrigation schemes utilizing the ground water cater to the isolated problem areas of chittor, Palakkad and Ponnani areas of Malappuram districts for irrigating garden crops.

(4) Exploring the possibilities of Kerala Bhavani Multipurpose Project may ultimately cater to the irrigation needs of 28000 ha of wet lands in Palakkad and Walluvanad District taluks.

3.1.11.2. Domestic And Industrial Purposes

The following recommendation given for meeting the future requirements of water for domestic and Industrial Purposes.

(1) The possibilities enhancing the supply from existing schemes may be explored based on more hydrological investigation.

(2) The surface flow and subsurface flow at Bharathapuzha and its tributaries may also be utilized for drinking water schemes.

(3) There may be provision to utilize water from different diversion schemes for drinking and industrial purposes during years.

(4) Ground water exploration to be taken upon priority basis.

3.1.11.3. Other purposes

Inorder to control the salinity intrusion problem, Chamravattom regulator cum bridge has been recommended. This may also cater to the fresh water need to the ponnani area of the Bharathpuzha basin.

3.2. Relevance Of Checkdams In Bharathapuzha

It is a common knowledge that where a river is flowing all through the year, generally there is no need for constructing dams in the river corse for storage except in situation where hydro-electric scheme has to be developed using such storage. All the Himalayan rivers are perennial in their flow due to the fact that snow belt helps keeping flow condition in the river during summer in the penisular India , South of Vindhya, all the rivers are to pass through period of dry conditions because of incidence of rian fall occurring in the monsoon lasting for six months.

The Bharathapuzha which is one of the largest river valleys in Kerala belongs to this category. For irrigation and water supply, the river flow is not available between January and June as the surface water flowing along the river ceases to operate soon after the end of the monsoon. Major irrigation projects such as Malampuzha were thought of and commissioned during the first and second planning periods. About 45000 hecters of land in this valley was intended to be covered by these irrigation schemes with a total storage of 300 Mm^3 comprising of 8 dams. The valley does not have further convenient locations for dam constructions to store more water. The result is that 7,848 Mm^3 of annual flow discharged directly into the sea is being wasted, without any gainful utilization.

To meet the demand of irrigation, water supply and other usages of water during six dry months(January to June), it is necessary to device other methods to retain path of the monsoon flow in this river system. In this perspective, adoptions of check dams is relevant. These will facilitate not only storage of some volume of water but also they will enable ground water table on either sides of the river to rise In such a condition, withdrawal of water from the river above the bed level will facilitate to meet the needs of irrigation and drinking water.

Locations, which are found to be suitable for construction of check dams/subsurface dams in Bharathapuzha river are shown in figure. 12

3.3. Necessity of Check Dams in Thrangali Kadavu

The site under this study is at Thrangali Kadavu in Vaniyamkulam Panchayath. The particulars observed at the site are as follows. A lift irrigation scheme is situated approximately 105 meters upstream of the proposed weir line. Also a drinking water scheme is situated approximately 1 km upstream of weir line. The water requirement for the first crop in Thrangali and Karikkad paddy fields, which sum up to 50 hectares of land , is found to be satiated by the lift irrigation scheme. The water scarcity occurs during the second crop in this area and is found that no water is available for irrigation of the third crop. It is also found that only 50 hectares is irrigable during second crop period by the scheme. If the check dam is constructed, lift irrigation scheme will be benefited by the availability of water for both second and third crops. This may also help in increasing the water level in ponds and wells along the rout of irrigation canals, which further benefits in irrigating rice, coconut, vegetables, banana, arecanut, etc.

If the check dam is constructed the drinking scheme will able to provide drinking water all round the year for Panjal, Muthalurkkara, Chelakkara and Vadakkanchery panchayaths in Trichur districts. Also the panchayaths Vaniyamkulam, Chathuvara and Anakandi in Palakkad district which have no permanent water supply scheme will also be benefited by this check dam.

From the fore going facts presented, it will become obvious that there is no alternative other than adoption of sub-surface dam at the particular site at Thrangali Kadavu in Bharathapuzha basin. Plate.1 shows location of the proposed site.

3.4. CONSTRUCTION OF SUBSURFACE DAM AT THRANGALI.

The proposed subsurface dam across the Barathapuzha is located near the Thrangali village which is on a village road taking of the state highway between Vaniyankulam and Shornur. A schematic figure representing the location of proposed dam is given in Fig 13. The river at the location flows in the South-North direction. A pump house for an irrigation scheme is located adjacent to the proposed dam on the left bank of the river.

The site proposed for the subsurface dam was fixed based on the following conditions.

1. Presence of a lift irrigation scheme about 100 m upstream of the dam, which is the major benifictory of the proposed sub-surface dam.
2. Presence of drinking water scheme about 1km upstream of the weir line

Topography of river and banks, soil properties, presence of traffic route, sand removal etc. were studied. According to the information obtained from the local survey, the site and the adjacent areas are subjected to sand removal from last 15 years. The other favourable features at this site is the opening up of the valley upstream of the site through the width is controlled at the axis by a rocky bank on the left side and a silty formation on the right flank which is sufficiently clayey to produce bricks in factory located on the right bank, near the axis and could expected to control the seepage around the ends at the axis. Another favourable feature is the existence of clay layer about 3 meters below the sand so that an impervious cut-off could be provided at a relatively low depth. Rocky formation was found at a depth of 6m at the right bank and 7m at the left bank. To minimize flooding in the banks with cultivated crops, it is desirable to have a minimum obstruction above the river bed during the flood season. For raising and regulating water flow during the low flow period, temporary structures with earth bunds or cribfilled structures above the bed are preferred and widely adopted in many countries. No obstruction to river flow is allowed during the flood season. At Thrangali it is proposed to keep the top of the permanent structure 0.5m above the level of footvalve of the pump used for irrigation scheme and this level more or less represents the low water level. During the summer, the water level can be raised by about one meter with the help of sand bags. This will provide storage and some flexibility for regulating low flows downstream. It is also predicted that any raising the level furthering the flood season will cause sand to be deposited up to that level. Even though some nominal openings are provided, the effect of such openings in clearing sand will be only local. Hence, in this construction it is not proposed to provide such type of openings.

The following investigations are required to be carried out to finalise the material specifications and to monitor the performance of the structure.

A. Monitoring of the existing and post structure ground water profile.
B. Drill holes to find the depth of clay level .
C. Laboratory investigations.
D. Water requirement details.
E. Construction details of subsurface dam.

3.5. Monitoring of the existing and poststuructure ground water profile.

This will be obtained by noting the depth of water level in each month in the adjoining wells, before and after the completion of the structure. Depth of water level in each month before construction is compared with the depth of water level after construction. The water level in the source of water which is used for irrigation purpose located near the proposed check dam is also to be noted . These results will provide an indication to the effectiveness of the check dam.

3.6. Dri.. holes to find the depth of clay level.

Four drill holes were taken up to the clay level. The average depth of clay level was found to be 3 m. Plate.2 shows the equipment arrangement for determination of clay level. Rocky formation was found at a depth of 6.m at the right bank and 7.m at the left bank.

3.7. Laboratory investigations.

The following laboratory investigations were done by using standard methods.

1. Determination of water content by Oven drying method.

2. Determination of specific gravity by Pyconometer.

3. Determination of specific gravity by Density bottle.

4. Determination of liquid limit of soil.

5. Determination of plastic limit of soil.

6. Determination of shrinkage factor of soil.

7. Determination of permeability by falling head method

8. Determination of grain size distribution by seiving.

9. Determination of grain size distribution by Pyconometer.

3.8. Water requirement details

3.8.1. Irrigation water needs.

Every crop requires a certain quantity of water after a certain fixed interval, throughout the period of growth. In a tropical country like India, the natural rain fall is insufficient or water does not fall in fixed interval, as required by the crops. The term water requirement of crops means the total quantity and the way in which a crop requires water, from the time it is sown to the time it is harvested. The water requirement may vary with the crop as well as with the place. In other words, different crops will have different water requirements, at different places of the same country, depending on the climate, type of soil, method of cultivation and useful rainfall. The water requirement of important crops in Kerala is given in Table 7.

Table 7.

1.	Rice	0.5 M litre/hectre (continuous)
2.	Coconut	0.106 - 0.258 M litre/hectre (3 to 9 days)
3.	Arecanut	0.3M litre/hectere (once in 5 days)
4.	Banana	0.1M litre/hectre (once in 2 days)

In order to meet the water requirement of various crops, the construction of sub-surface dam at the proposed site is a remedial measure. Panjal, Muthalurkkara, Chelakkara, and Vadakkanchery panchayaths in Thrissur Districts and Vaniyamkulam, Chavara and Anakandy panchayats in Palakkad district will get sufficient amount of water for irrigation and drinking purposes by the construction of this sub-surface dam. The water requirement of various crops and drinking water in these region is given in table 8.

Table 8.

SN.	Name of Crop	Area (Ha)	Water Requirements 10^6 lit/ha	Periodicity	Irrigation day/year water Requirement	Total 10^5 lit
1	Paddy	60.7	0.50	Continuous	210	6373.5
2.	Coconut	10.12	0.106 to 0.258	3 to 9 days	70	
3.	Arecanut	4.05	0.30	once in 5 days	42	128.93
4.	Banana	8.09	0.10	Once in 2 days	105	51.03
5.	Vegetables	6.07	0.25	Daily	210	84.95
						318.685

Grand Total = 6956.168×10^6

Total crop water requirement = $6956.168 \times 10^3\ m^3$

3.8.2. Drinking water needs

It is proposed to provide drinking water for 5000 pepole, living very near to the proposed site. Percapita drinking water requirement is assumed to be 210 litres/day.

Water requirement for drinking purpose

$$= 5000 \times 210 = 1050 \times 10^3$$

Total water requirement = $6956.645 \times 10^3 + 1050 \times 10^3$

$$= 8006.645 \times 10^3$$

$$= 8.006\ Mm^3$$

3.9. Constructional details of sub surface dam

Width of the river at the proposed site is 300m. It is proposed to provide an anchorage of 10m to the right and left bank of the river. Hence, the length of the sub-surface dam will be around 320m. From the observation wells it was found that stiff clay is present at an average depth of 3m. Hence, the dam is to be extended up to a depth of 3m below the ground level, so that it will rest on a hard strata. It is proposed to give a thickness of 0.6m for the sub-surface dam. Cross sectional view of the proposed sub-surface dam is given in Fig.14 . At the bottom of river slurry wall is protected by providing gabbion work. Gabbion work is to be provided for a length of 3m on the upstream side and 12m on the downstream side. Gabbion work is the arrangement of layers of packed rocks in well protected G.I net work.The gabbion, is rectangular wire mesh basket filled with stones, is the basic building block. Thease blocks, wired together in layers, form gabbion structures that are flexible and permeable. Gabbion weir is used as an effective solution to water erosion. Plate.3 shows the construction details of gabbion work. Both the left and right banks of the river is to be protected by providing gabbion work for a length of 25m.on upstream and downstream.

Planning and procedure for the construction of the sub-surface dam is as follows.

1. The trench construction is proposed from the left bank, while the gabbion work is to be concentrated in the right side.
2. The river diversion may be done through the central portion.
3. Prepare the sand platform for initially dumping the trenched material (Sand+bentonite) and then spreading over an area of roughly 7.0 m to 8.0 m. wide. The platform shall be made in the upstream along the trench side.
4. Prepare the bentonite slurry of 1.1 to specific gravity(roughly 175 grm bentonite in 1 litre slurry.) for trench stabilisation.
5. Make a 0.3.m deep and 0.6.m wide trench along the wall profile and then fill it with bentonite slurry.
6. Push more bentonite in to the sand using the slurry jet.

7. Excavate the trench up to the clay depth and may be little in to the clay.

8. The excavated sand that is mixed with some bentonite shall be stockpiled over the platform, prepared for mixing sand-bentonite-cement-clay grout.

9. Simultaneously spread the excalvated sand over the platform in to a 0.20.m thick layer.

10. Spread clay in small lumps and then spray water(10% clay)

11. Add more bentonite slurry and then run the roto tiller to make the mix somewhat even.

12. Spread the necessary cement (five-%) over the mix and then run the rototiller. Bentonite slurry may be added to make the consistency of the grout semi liquid.

13. Place dividing panel at about 5.0.m and grout is placed in the trench by pouring through a chute thus replacing the slurry. A tremmie can be used if necessary to maintain the proper consistency. Before placing the diaphragm material in the slurry filled trench it should be ensured that all the loose material on the surface to seat the diaphragm is removed.

14. Stir the grout manually by way of pushing the agitator up and down.

15. Continue making the trench for another 5.0m and continue grouting after isolating another 5.0.m stretch using another panel.

3.9.1. Estimation of quantity of material in the construction of sand-cement-bentonite grout wall.

A,quandity of slurry wall

=0.6x3.0x300

=540 m^3

b,quantity of cement,60 Kg/cumec.

=540x60

=32400Kg

c,Quandity of bentonite,68Kg/cumec.

=540x68 =36720Kg

3.10. Detailed procedure of construction of subsurface dam

3.10.1. Preparation of bentonite slurry

Equipment used

1	8HP SP3L mud pump	one number
2	200 litres MS or plastic drums	10 numbers
3	Cashureena poles of 1.5m long	10 number
4	2.5" Canvas hose pipe	150m and 20m piece
5	2.5" Rubber pipe lined with Nylon	20.0m
6	2" GI or MS pipe with bend	Two numbers of 3.0m long
7	Distribution box for bentonite mud	10 numbers
8	5 HP de-watering pump	10 numbers
9	LDP 150 micron sheet	100 sq. Metre

Slurry tanks are constructed near the trench for easy circulation of bentonite slurry in to the trench, which is shown in plate 4. Bentonite slurry pit of 5m.x5m.x.0.7m is to be cunstructed. The slurry pit is to be lined with an LDP 150 micron sheet and sides are protected by sand bags. Sand bags of 20 to 22 kg is to be used, so that bags can be placed flat for better stability. Schematic diagram of slurry tank showing all the arrangement is shown in Fig 15.

Initially bentonite is to be mixed in small quantities in 200 litre barrals and then fill the slury in the slurry pit. Now water is to be added so as to get the bentonite slurry of 1.1 to specific gravity. Slurry is to be mixed thoroughly by using a mud circulation pump keeping both the suction and delivery pipes inside the slurry pit. Move the suction and delivery ends in the slurry tank to cover the entire area for uniform mixing. The density of bentonite slurry shall be between 1.11 and 1.12. roughly 175 kg of bentonite is necessary to prepare 1 cumec slurry. About 9 cumec slurry may be necessary for circualtion through a stretch of 2.0.m. The slurry used in excavated portion is roughly 3.6 cumecs in this case and the remaining will be in the return channel and then to the slurry tank. About 1575 kg bentonite is to be mixed in 8.5 cumec water to prepaire 9 cumec slurry.

Bentonite slurry shall be prepaired at least 24 to 48 hours before the construction of the trench for proper mixing and expansion of bentonite

3.10.2. Construction of trench by using a Poclain

Equipment used

Poclain

A trench having width of 0.6m is to be constructed using poclain over a stretch of about 2 m. A schematic representation of making trench by using poclain is shown in fig 16. Plate 5.will give a clear picture about the construction of trench by using poclain.

The sides of the trench is to be protected by pumping the prepared slurry into the trench through a canvas pipe during the progress of excavation. The excess slurry will flow back to the slurry tank through the return channel. The sand deposited along the channel shall be revmoved and can be used in making the slurry wall grout. Add required bentonite slurry prepared in the barrels to compensate the loss in the process. The process of circulation of slurry is shown in Fig 17. and Fig 18.

3.10.3. Replacement of the bentonite slurry with sand-cement-bentonite-clay mix.

This include mixing of sand,cement, bentonite and soil to prepare the grout mix and placement of prepared grout in the trench using tremmie.

Equipment used

1.	JCB with 4.0m to 4.50m extendable arm,	One number
2.	Roto Tiller for mixing the grout.	One number
3.	2" GI or MS pipe with bend	Two numbers of 3.0m long
4.	Tremmie funnel with pipe	Two numbers
5.	6.0m high Tripods with 200mm pulley, For handling the tremmey	Two numbers
6.	Manila rope	30 metres

7.	2.5" Canvas hose pipe,	150m and 20m piece
8.	Guide plates for the trendch,	Four numbers of 5.0 m each
9.	5HP de-watering pump,	One number
10.	Poking rod	One number
11.	Empty gunny bags	App. 2000 Nos

3.10.3.1. Preparation of grout mix

Preparation of grout mix is to be done as follows

1. Excavated snad is to be spread over an area of 7m x 7m
2. Clay lumps brocken into small pieces is to be spread over the sand layer.
3. Cement is to be spread over the clay soil
4. Roto tiller is to be run to dry mix the material, shown in Plate .6
5. Bentonite slurry of adequate bentonite content is to be spread over the mixed material and run the rotor.
6. Grout is to be prepared to the flowing consistancy and is to be fed by gravity into the tremmie. Construction details of the tremmie is shown in Plate .7
7. The grout is to be mixed in the trench by mixing device, for uniform mixing. Contruction details of mixing device is shown in Fig.19 and Plate .8

One m^3 of the grout mix prepared of sand-cement-bentonite grout is in the proportion of

sand : 1500 kg/cumec
cement : 60 kg/cumec
Bentonite: 68Kg/cumec
water : 450 litres/cumec

The total volume of all the ingradients in the grout will be eaqual to 1000litre or $1m^3$

$$V = 1500/2.8 + 60/3.2 + 68/3 + 450$$

$$= 1027 \text{ litres, say } 1m^3$$

where 2.8 is specific gravity of sand, 3.2 is specific gravitiy of cement and 3 is specific gravity of bentonite.

3.10.3.2. Circulation of grout mix in the trench

The trench may be progressed for about 5m length before the circulation of the grout. Place three isolation panels at an interval of 50 cm to 60cm dividing the trench in to eight to ten parts. Place the tremmie in the first panel and replace the bentonite slurry by the grout. Remove the tremmie and then place it in the second panel and then in the third panel and so on. A schematic representation is shown in Fig 20. The over flowing bentonite slurry shall be re-routed through the return channel.

Thus the construction of sand-cement-bentonite grout wall is completed

3.11. Protection of left and right banks of the river

The left and right banks of the river is protected by providing gabbion work on both upstream and down stream sides of the dam. The construction details of side protection is given in Fig 21. The height of gabbion work is extended up to the high flood level and for better stability it is anchored in to the soil as shown in Fig 21. Plate.9 will give a clear picture about the construction details of side protection work

In order to protect diaphram wall from scour due to degradation of river bed down stream, an apron structure consisting of soil-cement nearly 4m wide has been provided and tied to diaphram with a 2m wide soil-cement blanket. The weir crest 0.5m high will rest on this apron. Soil cement concrete weir body is to be constructed by using 1600 Kg of sand, 120 Kg of cement, 120 Kg of clay for $1m^3$ Soil cement concrete. Consolidation of the ingradient is to be done by using a vibratory plate compactor, which is shown in Fig22. To minimise the dewatering, the energy dessipation arrangement will be gabbion lined cistern 1m deep below the low water level. The rock in the gabbions will be sluised with sand. The length of the cistern will be about 4m. So the bed will launch itself during the higher floods. The maximum depth of scour is expected to be about 6meters for the maximum observed flood of about 3000 cumecs. The cistern depth would be adequate for the annual flood. The abutments is proposed to be protected by gabbion slope protection works with a launching apron of the same material.

RESULTS AND DISCUSSION

Various field investigations done, cost analysis and effectiveness of check dams are discussed in this chapter. The results obtained are given below

4.1. Laboratory investigations

Following investigations were done to get a clear idea about the selection of proper material and also for proper planning

1. Determination of water content by Oven drying method.
2. Determination of specific gravity by Pyconometer.
3. Determination of specific gravity by Density bottle.
4. Determination of liquid limit of soil.
5. Determination of plastic limit of soil.
6. Determination of shrinkage factor of soil.
7. Determination of permeability by falling head method
8. Determination of grain size distribution by seiving.
9. Determination of grain size distribution by Pyconometer.

The results of all these experiments are given in Appendix 1. Based on all these results it was found that most suitable grade of bentonite for the proposed sub-surface dam is ultra bond and high bond type bentonites.

4.2. Cost analysis of proposed subsurface dam

Cost analysis of various components of sub -surface dam was done. The detailed estimate of the same is given in Appendix 2 and the abstract of the estimate is given below.

4.2.1. Construction of impermeable sand- cement-bentonite wall

4.2.1.1. Filling and forming sand-Cement-bentonite grout subsurface dam 0.60m wide, depth up to the clay level at site(average 3m depth) after excavation of sandy soil in or under water by using poclain placing isolation panel at average 2m length. Add stones in to the trench allowing cement-bentonite slurry to over flow in to the collection pit, add sand escavated from the trench using poclain and mixing in the slurry. Continue the procedure of sand mixing and removing the panel and then is used in another stretch.

Volume of excavation for sub surface wall : 320x0.6x3.0 =576

Taking Cost of excavation for sub-surface wall as Rs. 1221/m^3

Total cost of excavation = 1221 x 576 = Rs. 703296

4.2.1.2. Pulling up ring bund with sand filled bags having average width of 1.5m and height 1.00m and removing after completion of work for diverting water.

Total length of bund =310m.

Cost of construction of bund and removal of the bund after completion of sub-surface dam = Rs. 3118 /10m

∴ cost of construction for 310 m = (310/10) x 3118 = Rs. 96,658

Hence total cost for construction of sand-cement- bentonite wall

= 703,296 + 96,658

= Rs.799,954

4.2.2. Construction of soil cement weir body.

4.2.2.1. Soil-cement-concrete weir body using 1600 Kg of sand, 120 Kgs cement 120 Kgs of clay for 1 m3 of soil cement concrete mixing , by machine mixing placed in position.

Weir body sloping position : 300.00x6.60x0.40=792.00 m^3

Top of way : 300.00x0.75x0.15 = 33.75 m^3

Total = 825.75 ≈ 826 m^3

Cost of construction of soil cement weir body = Rs. 733/ m^3

Hence, total cost of construction soil cement weir body = 733 x 826 = Rs. 605,458

4.2.3. Gabbion works

4.2.3.1. Earth work excavation in sandy soil including in or under water.

Earth work excavation for foundation = 300.00x15.35x1.00 = 4605 m^3

Cost of earth work excavation = Rs. 251/10m^3

Hence total cost of earth work excavation = (251/10) x 4605 = Rs. 115,586

4.2.3.2. Dry rubble work for Gabbion works swiced with sand including all cost conveyance and labour charges.

Total volume of dry rubble work for gabbion work

Down stream of subsurface dam	:	300x3.00x0.50	=450.00
Down stream of subsurface dam	:	300x3.00x0.50	=450.00
Weir body	:	300x0.75x1.00	=225.00
Weir body	:	300x0.75x1.00	=225.00
Down stream slopping position	:	300x2.00x0.50	=300.00
Down stream of apron	:	300x5.00x0.50	=750.00
		Total	= 2400m^3
Hence total volume of dry rubble works			=2400.00m^3
Cost for dry rubble works			= Rs. 368/m^3

Hence total cost for dry rubble works = 368 x 2400.00

= Rs. 8,83,200

4.2.3.3. Supplying and making 2.00mm thick G.I wire net 100x120mm spacing,used for gabbion works, including all cost and conveyance and labour charges.

Volume of G.I net work = 2400 m^3

7 Kg of G.I. wire/m^3 is required.

Hence total quantity of G.I. wire required = 7 x 2400 = 16800 kg = 168 Qtl

Cost of construction of G.I. wire net = 3540/Qtl

Hence total cost of G.I. wire net 3540 = 3540 x 168 = Rs. 594,720

Hence total cost for Gabbion works = 115,586+883,200+594,720

= Rs. 1,593,506

4.2.4. Side protection works

4.2.4.1. Earth work excavation in sandy soil including in or under water.

Volume of foundation, 2 sides = 2[50 x 5.00 x 0.50+ 50 x 3 x 0.50]=400m^3

Cost of excavation of 10m^3 = Rs. 251

Hence, total cost of earth work = (251/10) x 400 = Rs. 10040

4.2.4.2. Dry rubble work for side protection by providing Gabbion network including all cost and conveyance and labour charges.

Volume of rubble work for two sides

=2x50x0.5[3+5+4+3.5+3+2+2+2+2]

=1325m^3

Total volume of dry rubble work = 1325m^3

Taking Rs.368/m^3 ,for dry rubble work

Total cost for dry rubble work = 1325x368 = Rs.487600.

4.2.4.3. Supplying and making 200mm thick G.I wire net, 10x120m spacing fixing for gabbion works, including all cost and conveyance and labour charges.

Total G.I wire net supplied = 1325m^3

Taking 7 Kg/m^3, total quantity G.I wire net required = 7x1325=9275=92.75Qtl.

Cost of construction of G.I wire net= Rs3540/Qtl.

Hence total cost of construction of G.I net work = 3540x92.75 = Rs.328335

Hence total cost for side protection works = 10040+487600+328335

=Rs. 825,975

Now total cost for construction of subsurface dam= 799954+605458+ 1593506+825975 = Rs.3,824,8 93

The estimated cost is comparatively lesser than that of the total cost for the construction of a a conventional concrete check dam. This type of check dams are cheap, economical, eco- friendly and fast method of construction. Hence this type of dams can be used at various locations in the rivers of Kerala for proper water harvesting, which will help to full fill our water needs in summer. So, this method construction should be strongly recommended promoted and popularised.

4.3. EFFECTIVENESS OF CHECK DAMS.

Effectiveness of the proposed dam was analysed based on the performance of check dam constructed at Lakkidi. The performance of Lakkidi check dam was studied by conducting a local investigation. From the study it was revealed that the water level in the adjoining wells were found to be increased during summer by about 2 feet. The water level of the well constructed on the upstream of the dam, which is using for drinking water supply was also studied. It was realised that, before the construction of the dam water was available only for about 2 hours pumping. But after the construction of the dam water is available for continuous 24 hours pumping.

From this results it is concluded that the lift irrigation scheme and water supply scheme located in the upstream will be highly benefited by the construction of subsurface dam. It is also assumed that the water levels in the adjoining will also be increased. A study is already started to analyse the effect of subsurface dam, by monitoring the water level in the adjoining wells, the source used for lift irrigation scheme and the well utilised for the drinking water supply, before and after the construction of the dam. This will give a clear indication about the effectiveness of the subsurface dam.

SUMMARY AND CONCLUSIONS

A general study of Bharathapuzha was done and it was found that most part of Bharathapuzha is getting dary during summer season do to the improper management. If proper water conservation techniques are adopted these problems can be solved effectively. Considering unique characteristics of Kerala, most suitable method for water management of rivers is the construction of check dams/sub-surface dams. As a part of this 14 locations were selected in Bharathapuzha, which are found to be suitable for the construction of check dams/subsurface dams.

The characteristics of the basin, the flow characteristics and other relevant aspects are studied for site selection and construction of the sub-surface dam.

Based on the various field investigations and laboratory investigations it was found that Thrangali Kadavu is suitable location for construction of sub-surface dam.

Cost analysis of sub-surface dam is done. It is found that this type of checkdams are cheap, economical , eco-friendly and fast method of construction. Hence, this type of dams can be used at various locations in the rivers of Kerala for proper water harvesting; which will help to fulfil our water needs in summer. So, this method of construction should be strongly recommended, promoted and popularised.

Monitoring of water level in the adjoining wells and water source for irrigation and drinking water supply schemes is essential for studying the effectiveness of checkdam.

This type of water harvesting can be taken as a guide line for other rivers of Kerala.

REFERENCES

Al-Hassoun,S.A. and Al-Turbak,A.S.1995.Recharge dam efficiency based on sub surface flow analysis. Water - International. 20(17). pp.40-45.

*Armonia,R.C.and Operio,S.C.1987.The soil and water conservation project Sto.Domingo,Albay.Rural-Reconstruction-review.pp.47-50.

Augson.G.George, Santhosh joseph, Shiju Thomas and Simi,V.U. 1997. Study Of Bharathapuzha And Design Of a Checkdam. B.Tech project report. Govt. Engineering College,Trissure.

Bajwa,S.S. and Narda,N.K.1993. Silting of small check dams for water harvesting in the Kandi region of Punjab(India) using remote sensing. International- Journal- Of-Tropical- Agriculture. 11(3).pp.168-171.

Billin,M.H. and Booklis,P.H. 1991. Management of artificial underground reservoirs for irrigation. Proceedings of international commission on irrigation and drainage special technical session, Beijing.

*Ciarl,M.1985.Gabbion weirs in water erosion control projects, design and construction criteria.erosion-control:-a-chellenge-in-our-time.pp.85-103.

Frank Harris. 1980. Ground Engineering Equipment and Methods. The Choucer Press Ltd.Bungay.

Geol, P.K., Samra, J.S., and Bansal, R.C. 1996. Sediment retention by gabbion structures in Bunga watershed. Indian Journal of Soil Conservation. 24(2). pp.107-110.

*Guiraud, R., Paepe, R., and Jel gersma, S. 1989. Small dams and sub surface dams in arid and semi arid areas. Proceedings of NATO advanced research workshop of geohydrological management of sea level and mitigation of drought.

James,E.J., Remani,K.N., and Harikumar, P.S. 1998. Water scenario of Kerala. The state committee on Science Technology and environment.

Kozak, J., Palel,L. and Reznanicek, R.1988. Effect of bentonite addition on soil physical properties and physical retention of Nitrate, physical properties of agricultural materials and products. Proceedings of third international conference.

*Leu - Chenghua., Leu, C.H., Tesai, H.Y. and Chang, S.H. 1995. Site selection of checkdams based up on geographical information systems. Journal of Chinese soil and water conservation.
26(1). pp.49-55.

Liu.C.M., Lin.Y.L., longhlin.C., and Pearce, A.J. The effectiveness of stilling ponds and concrete blocks in dissipating the overflow energy of checkdams. Symposium on effects of forest land on erosion and slope stability. pp .241-245.

Masanori, S. 1997. Effects of crack propagation behavior on mechanical properties of concrete checkdams. Bulletin of the forestry and forest products research institute, Ibaraki. pp .73-103.

Punmia,b.c.Ashok Kumar Jain.Arunkumar Jain.1979.Lakshmi Publication Ltd.New Delhi.

*Vipulanandan,C. and Leung, M. 1991. Seepage control in contaminated and permeable Houston clay, a laboratory study. Hazardous waste - Hazardous materials. 8 (1).pp .17-32

Visalakshi, K.P., Thomas.J., and George, T.P.,1986. Water harvesting by sub surface dike. Kerala Agricultural University, Vellanikkara.

* Originals not seen

APPENDIX I

LABORATORY INVESTIGATIONS

A. Determination of moisture content by oven drying method

Silty Clay Soil

Sample No.	Container + Wet Soil (gm)	Container + Dry Soil (gm)	Weight of Contairer (gm)	Mositure content (%)
1	90.19	78.43	11.92	17.68
2	45.12	40.01	7.8	17.73
				Avg=17.765%
Sandy Soil				
1	57.97	56.93	16.51	2.573
2	73.42	72.04	17.83	2.546
				Avg=2.559%

Results

Moisture content of Silty Clay = 17.765%

Moisture content of Sandy Soil = 2.556%

B. Determination of specific gravity by pycnometer.

Silty clay

Test No.1

Mass of pycnometer (M_1) g = 418

Mass of pycnometer + Soil (M_2) =719

Mass of pycnometer + Soil +Water (M_3)g =1633

Mass of pycnometer + Water (M_4) g =1454

∴Specific gravity

$$G = \frac{M_2 - M_1}{(M_2 - M_1) - (M_3 - M_4)}$$

$$= \frac{(719 - 418)}{(719 - 418) - (1633 - 1454)}$$

$$= 2.467 \cong 2.47$$

Test No 2

M_1(gm) = 418

M_2(gm) = 722

M_3(gm) = 1638

M_4(gm) = 1454

∴Specific gravity

$$G = \frac{M_2 - M_1}{(M_2 - M_1) - (M_3 - M_4)}$$

$$= \frac{(722 - 418)}{(722 - 418) - (1638 - 1454)}$$

$$= 2.533 \cong 2.53$$

∴ Average Specific gravity = (2.47+2.53) / 2

= 2.50

Sandy Soil

M_1 = 424gm

M_2 = 828gm

M_3 = 1715gm

M_4 = 1465gm

∴Specific gravity

$$G = \frac{M_2 - M_1}{(M_2 - M_1) - (M_3 - M_4)}$$

$$= 2.62$$

C. Determination of specific gravity by density bottle method

Silty Clay

Sample 1

Mass of density bottle (M_1) gm	=	28.9
Mass of bottle +d Soil (M_2) gm	=	46.1
Mass of bottle +Soil +Water (M_3) gm	=	88.9
Mass of bottle +Water (M_4) gm	=	78.6

∴ Specific gravity

$$G = \frac{M_2 - M_1}{(M_2 - M_1) - (M_3 - M_4)}$$

$$= \frac{46.1 - 28.9}{(46.1 - 28.9) - (88.9 - 78.6)}$$

$$= 2.49$$

Sample: 2

(M_1) gm = 28.9

(M_2) gm = 47.4

(M_3) gm = 89.73

(M_4) gm = 78.6

Specific Gravity $G = \frac{M_2 - M_1}{(M_2 - M_1) - (M_3 - M_4)}$

$= 2.51$

Average specific Gravity G= 2.50

Sandy Soil :-

Sample : 1

M_1 = 14.9gm

M_2 = 39.09gm

M_3 = 86.75gm

M_4 = 71.89gm

Specific Gravity $G = \frac{M_2 - M_1}{(M_2 - M_1) - (M_3 - M_4)}$

= 2.618

Sample :2

M_1 = 14.9gm

M_2 = 41.1gm

M_3 = 88.04gm

M_4 = 71.8gm

Specific Gravity $G = \frac{M_2 - M_1}{(M_2 - M_1) - (M_3 - M_4)}$

= 2.63

∴ Averge Specific Gravity = 2.62

Results :

Average specific gravity of Silty clay = 2.50

Average specific gravity of Sandy soil =2.62

D. Determinatoin of liquid limit

Sandty Soil

Sample No.	Mass of container +wet soil (gm)	Mass of container+ dry soil(gm)	Mass of container (gm)	No. Of Blows
1	21.05	22.44	11.9	39
2	16.25	14.94	7.78	38
3	32.62	29.43	16.52	12
4	29.96	27.45	17.84	6
5	28.68	24.20	9.77	5

Water content %

Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
7.142	18.296	24.709	26.118	31..46

Liquid limit of sandy soil = 20.9%

Silty Clay

Sample No.	Mass of container +wet soil (gm)	Mass of container+ dry soil(gm)	Mass of container (gm)	Water content(%)	No of Blows
1	28.7	25.55	15.16	30.318	46
2	19.4	17.30	12.10	40.385	44
3	16.48	13.86	7.54	41.450	20
4	15.78	13.26	7.79	46.069	15
5	16.34	13.37	7.48	50.424	12

The liquid limit of sily soil is 38.6%

E. Determination of plastic limit

Silty Clay

Sample No.	Mass of container +wet soil (gm)	Mass of container+ dry soil(gm)	Mass of container (gm)	Water content %
1	15.10	14.37	9.19	14.093
2	16.20	15.33	9.20	14.92
				Avg = 14.113%

Plastic Limit = 14.113%

F. Determination of shrinkage factor

a. Water content of wet soil pat

Mass of shrinkage dish = 42.61 gm

Mass of shrinkage dish + wet soil pat = 81.64 gm

mass of shrinkage dish+dry soil pat = 70.61 gm

Mass of dry soil pat (M_d) = 28gm

Mass of water = 11.03

Water content of soil pat (w) = (11.03 x100)/28 = 39.39%

b. Volume of wet soil pat

Mass of mecury filling shrinkage dish

+ Mass of evaporating dish = 514 gm

Mass of evaporating dish = 147.39 gm

Mass of mercurry filling shrinkage dish = 324 gm

Volume of wet soil pat (V) = 324/13.6 = 23.8 cm^3

c. Volume of dry soil pat

Mass of mercury displaced by dry

soil pat + Mass of evaporating dish = 542 gm

Mass of evaporating dish = 320 gm

Mass of mercury displaced by dry soil pat = 222gm

volume of dry soil pat (V_d) = 222/13.6 = 16.32

d. Shrinkage limit

$$W_s = W - [\frac{V - V_d}{M_d}] \times 100$$

$$= 0.394 - \left[\frac{23.8 - 16.32}{28}\right]$$

$$= 12.7\%$$

Shrinkage limit of silty clay soil = 12.7%

G. Determination of permeability by faling head method

Sandy soil

Area of stand pipe (a) = 7.0686cm^2

Cross sectional area of soil sample (A) = 92cm^2

Length of sample (L) = 12.5 cm

Test No.	Initial head h_1 (cm)	Final head h_2 (cm)	Time taken t(sec)	Coefficient of permeability (cm/sec)
1	10	30	12	0.0878
2	10	30	11	0.0958
3	10	30	12	0.0878
				Avg= 0.0905cm/sec

Silty clay

Area of sand pipe (a) = 0.7854 cm^2

Cross sectional area of soil sample (A) = 92 cm^2

Length of sample (L) = 12.5 cm

Test No.	Initial head h_1 (cm)	Final head h_2 (cm)	Time taken t(sec)	Coefficient of permeability (cm/sec)
1	10	20	72	1.026×10^{-3}
2	10	20	73	1.012×10^{-3}
3	10	20	73	1.012×10^{-3}
				Average = 1.017×10^{-3} cm/sec

Results

Coefficient of permiability of sandy soil = 0.0905 cm/sec

Coefficient of permiability of silty soil = 1.017×10^{-3} cm/sec

H. **Determination of grain size distribution by sieving**

Sand soil

IS sieve	Particle size D (mm)	Mass retained (gm)	% retained	Cumulative % reatined	Cumulative % finer (N)
4.75mm	4.75mm	11	1.1	1.10	98.9
2mm	2mm	21.3	21.3	3.23	96.77
1mm	1mm	219	21.9	25.13	74.87
600mic	0.6mm	117.5	11.75	36.88	63.12
425 mic	0.425mm	372	37.2	74.08	25.9
300 mic	0.300mm	160.2	16.02	19.10	9.9
212 mic	0.212mm	85	8.5	98.6	1.4
150 mic	0.150mm	10.5	1.05	99.65	0.35
75 mic	0.075mm	3.08	0.308	99.958	0.042
Below 75mic	<0.075mm	0.25	0.025	99.983	0.017

Inference : From the graph it is seen that the soil is well graded, and

D_{10} = 0.3

D_{60} = 0.59

Uniformity coefficient (C_u) = D_{60}/D_{10} = 0.59/0.3 = 1.967

I. **Grain size distribution byhydro meter**

Calibration of hydrometer

Initial reading of water level (a) = 800

Reading of water level after immersing hydrometer (b) = 8.80

Volume of hydrometer = (b) - (a) = 80ml

= $80cm^3$

istance between 2 graduation s of cylinder = 0.2 cm

Cross sectional area = Volume between two graduations / Distanc = 10ml/0.2.

= $10cm^3/0.2cm$ = $50cm^2$

Height of bulb, h = 15cm

Height between neck of hydrometer is H

Calibration constant $= \frac{1}{2}\left(h - \frac{V_h}{A}\right)$

$= \frac{1}{2}(15 - 80/50)$

$= 6.7$

$H_e = H + \text{constant}$

Hydrometer readings (Rh)	H(cm)	Effective depth H_e (cm)
30	0.5	7.2
25	2.2	8.9
20	3.9	10.6
15	5.7	12.4
10	7.4	14.1
5	9.1	15.8
0	10.9	17.6
-5	13.2	19.9

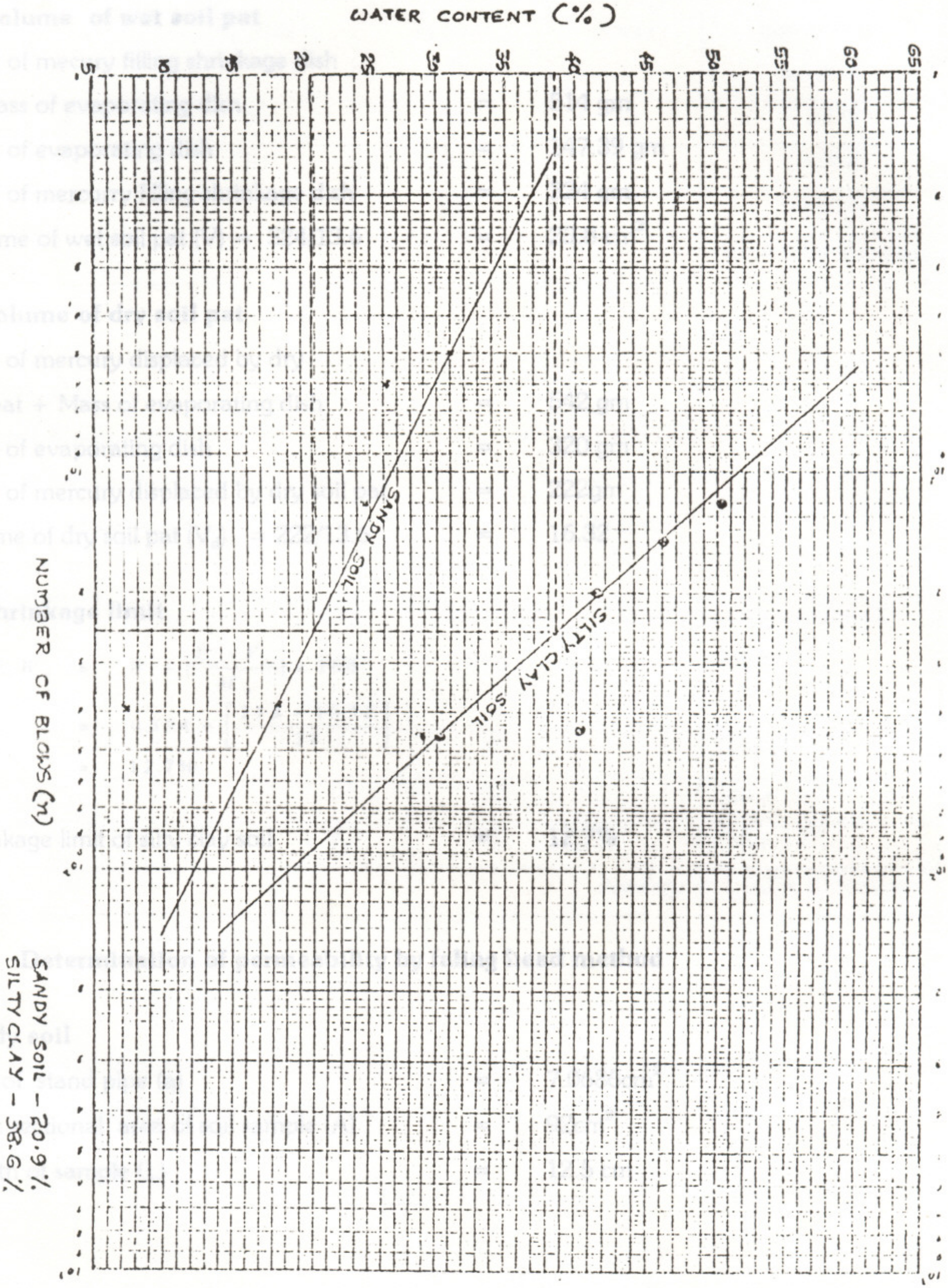
Meniscus correction

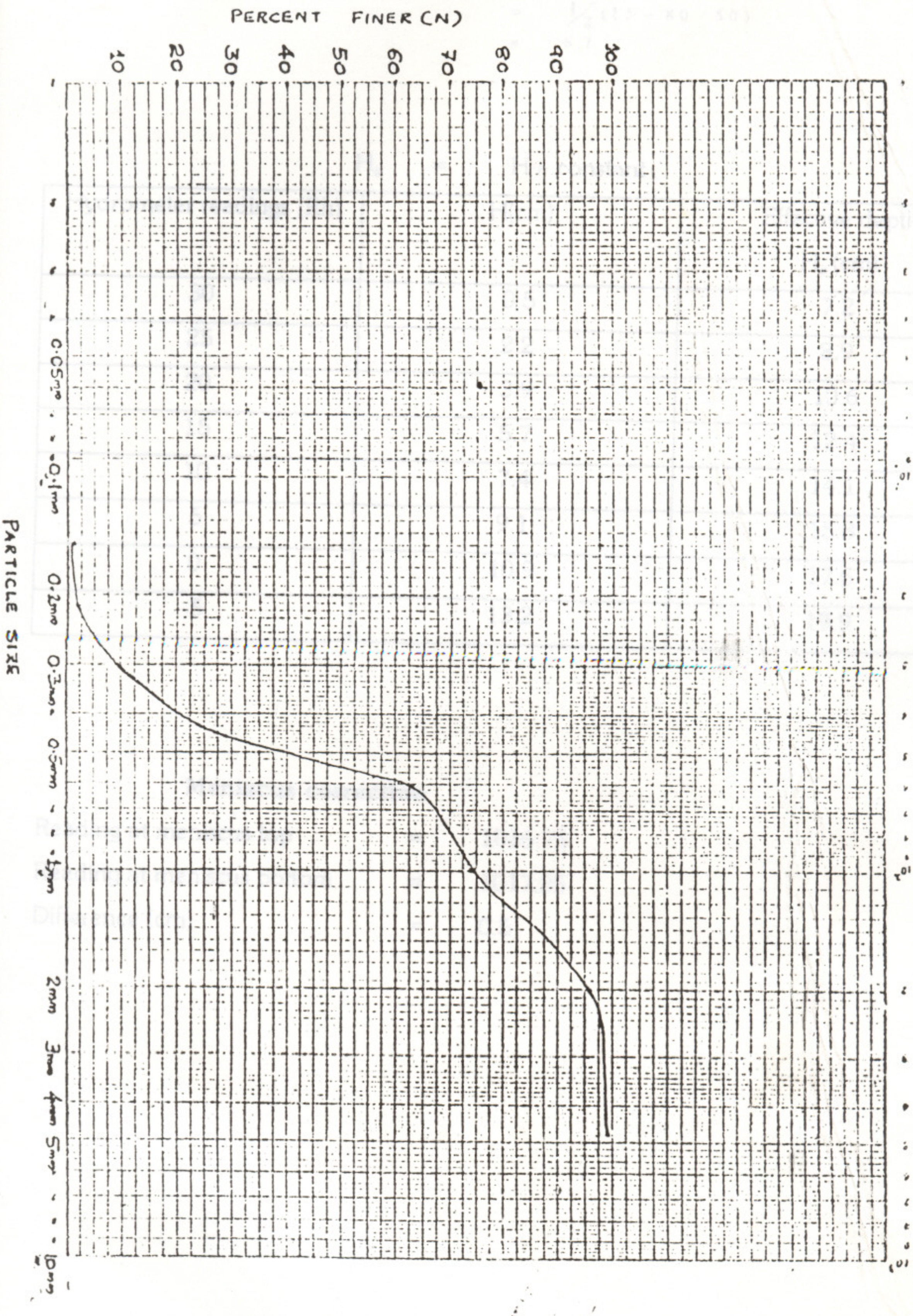
Reading at meniscus top = 1016.75

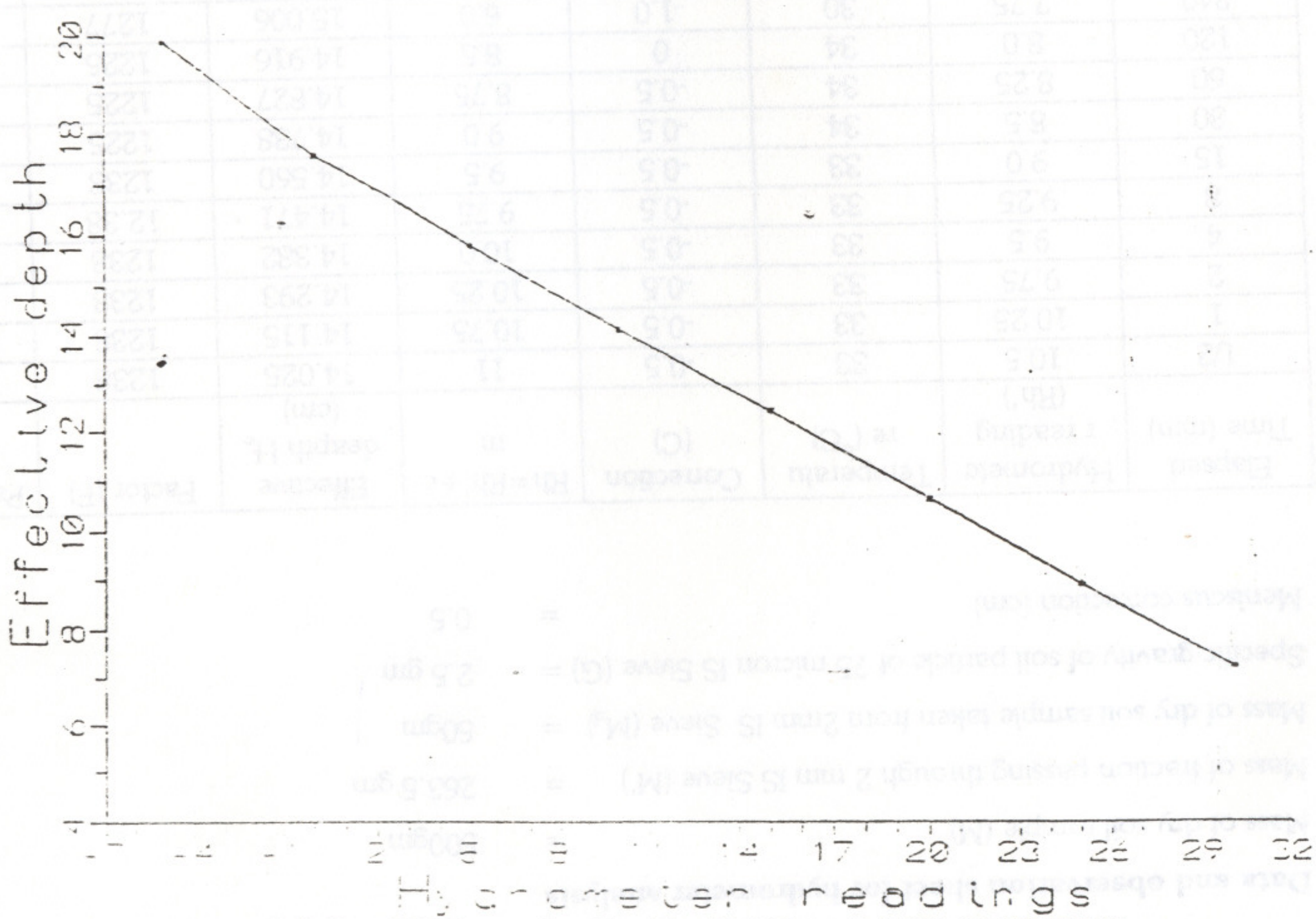
Reading at meniscus bottom = 1017.25

Difference (cm) = 0.5

DETERMINATION OF INDEX PROPERTIES




PERCENT FINER (N)
10
20
30
40
50
60
70
80
90
100
PARTICLE SIZE
0.05mm
0.1mm
0.2mm
0.3mm
0.5mm
1mm
2mm
3mm
4mm
5mm
10mm



CALIBRATION CURVE FOR HYDROMETER

Data and observation sheet for hydrometer analysis

Mass of dry soil sample (M)	=	500gm
Mass of fraction passing through 2 mm IS Sieve (M')	=	263.5 gm
Mass of dry soil sample taken from 2mm IS Sieve (M_d)	=	50gm
Specific gravity of soil particle of 75 micron IS Sieve (G)	=	2.5 gm
Meniscus correction (cm)	=	0.5

Elapsed Time (min)	Hydrometer reading (Rh')	Temperature (°C)	Correction (C)	Rh=Rh'+cm	Effective deapth H_e (cm)	Factor (F)	Particle size D (mm)	R=Rh'+C	% finer (N') based on M_d
1/2	10.5	33	-0.5	11	14.025	1238	0.0656	10	33.33
1	10.25	33	-0.5	10.75	14.115	1238	0.0465	9.75	32.5
2	9.75	33	-0.5	10.25	14.293	1238	0.0331	9.25	30.83
4	9.5	33	-0.5	10.0	14.382	1238	0.0235	9.0	30.0
8	9.25	33	-0.5	9.75	14.471	12.38	0.0167	8.75	29.17
15	9.0	33	-0.5	9.5	14.560	1238	0.0122	8.5	28.33
30	8.5	34	-0.5	9.0	14.738	1225	0.0086	8.0	26.67
60	8.25	34	-0.5	8.75	14.827	1225	0.0061	7.75	25.83
120	8.0	34	0	8.5	14.916	1225	0.0043	7.5	25.0
240	7.75	30	-1.0	6.0	15.006	1277	0.0032	7.25	24.17
6600	7.5	30	-1.0	6.5	15.095	1277	0.0019	7.0	23.33
1305	7.25	31	-1.0	6.25	15.184	1264	0.0013	6.75	22.5

Data and observation sheet for hydrometer analysis

Mass of dry soil sample (M) = 500gm

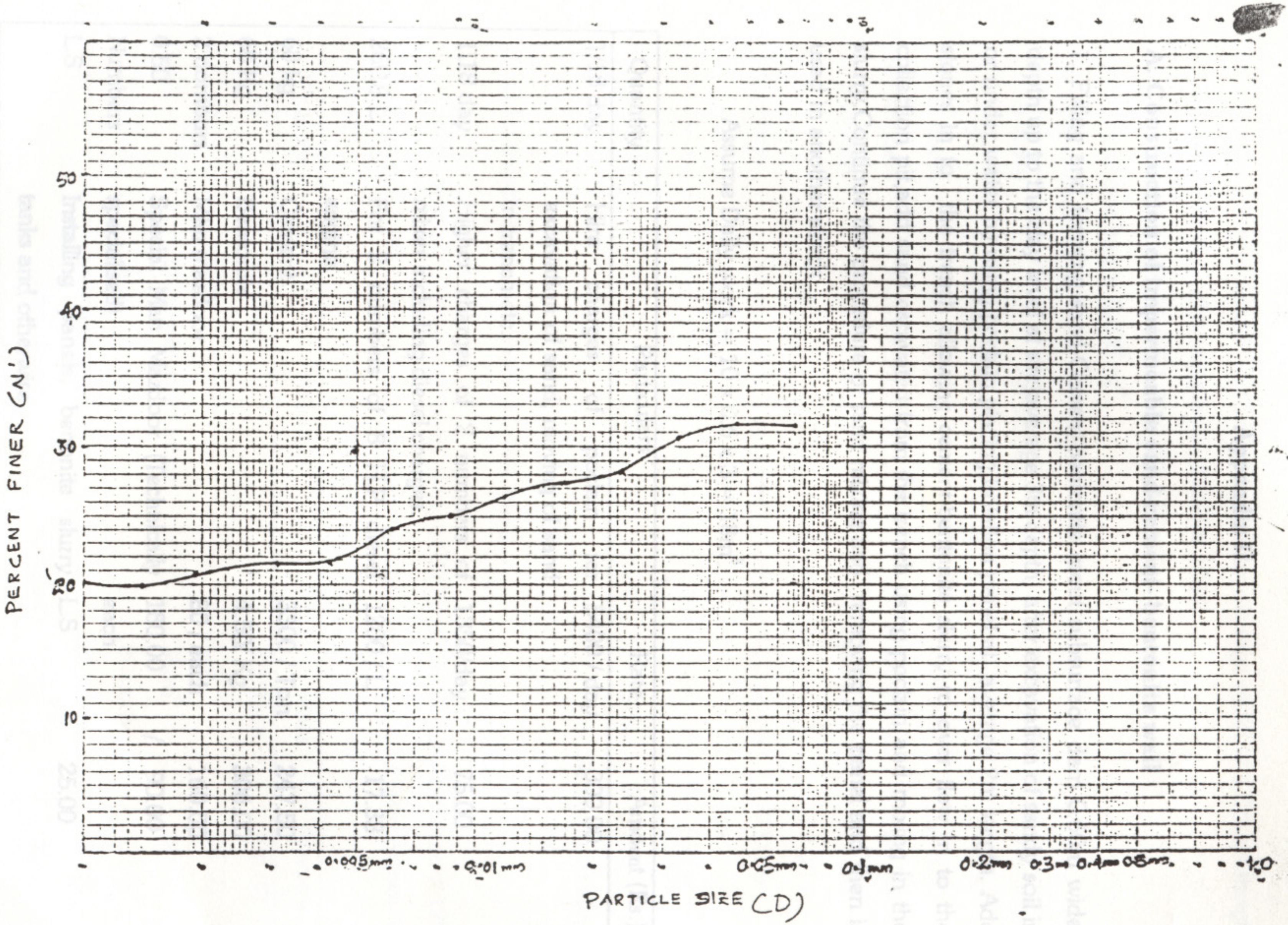
Mass of fraction passing through 2 mm IS Sieve (M') = 263.5 gm

Mass of dry soil sample taken from 2mm IS Sieve (M_d) = 50gm

Specific gravity of soil particle of 75 micron IS Sieve (G) = 2.5 gm

Meniscus correction (cm) = 0.5

Elapsed Time (min)	Hydrometer reading (Rh')	Temperature (°C)	Correction (C)	Rh=Rh'+cm	Effective deapth H_e (cm)	Factor (F)	Particle size D (mm)	R=Rh'+C	% finer (N') based on M_d
1/2	10	33	-0.5	10.5	14.025	1238	0.0656	9.5	31.67
1	10	33	-0.5	10.5	14.025	1238	0.0464	9.5	31.67
2	10.25	33	-0.5	10.75	13.936	1238	0.0327	9.25	30.83
4	9	33	-0.5	9.5	14.382	1238	0.0235	8.5	33.33
8	8.75	33	-0.5	9.25	14.471	1238	0.0167	8.25	27.5
15	8.5	34	-0.5	9.0	14.560	1225	0.0121	8.0	26.67
30	8.0	34	-0.5	8.5	14.738	1225	0.0086	7.5	25.0
60	7.75	34	-0.5	8.25	14.827	1225	0.0061	7.25	24.17
120	7.0	34	-0.5	8.5	14.738	1225	0.0043	6.5	21.67
240	7.5	34	0	7.0	15.273	1225	0.031	6.5	21.67
6600	7.25	30	-1.0	7.75	15.006	1277	0.0019	6.25	20.83
1305	7.0	31	-1.0	7.5	15.095	1264	0.0014	6.0	20.0



PARTICLE SIZE DISTRIBUTION CURVE OF SILTY CLAY.

Appendix II

A. Construction of impermeable sand-cement- bentonite wall

1. Filling and forming sand-Cement-bentonite grout subsurface dam 0.60m wide, depth up to the clay level at site(average 3m depth) after excavation of sandy soil in or under water by using poclain placing isolation panel at average 2m length. Add stones in to the trench allowing cement-bentonite slurry to over flow in to the collection pit,add sand escavated from the trench using poclain and mixing in the slurry.Continue the procedure of sand mixing and removing the panel and then is used in another strech.

Assume Daily work = 10 x 0.6 x 3.= 18m^3

Quantity	Particulars	Rate	Amount (Rs.)
1/18 day	Hire charges of poclain for excavation of sand, moving of sand in trench etc.	5400 / day	300.00
1\18 day	Higher charges of 2 numbers of mixer including diesel charges.	1350/day	75.00
26\18 L	For 2 numbers of 8 H.P diesel engine.	1200 / L	17.33
60 kg	Cement	3300 / Ton	247.50
68 Kg	Bentonite	4.50/ Kg	306.00
2 nomburs	Man mazdoor	80 / each	160.00
0.50 Numbers	Special Man Mazdoor (Technically specialised)	180.00 / each	90.00
L.S	Installing panels, benonite slurry tanks and otherwise	L.S	25.00

Total = 1220.83

= Rs. 1221

2. Putting up ring band with sand filled bags to an average width of 1.5m andheight 1m and removing after completion(Rate for 10m)

Quandity of bund =1x10.00x1.50x1.00 =15 m^3

Quantity of one bag = 0.035 m^3

Number of bages required = 428 bags

Quantity	Particulars	Rate	Amount (Rs.)
428 bags	Empty cement bags	1.00/each	428.00
15 Numbers	Men for filling	80.00/each	1200.00
10 Numbers	Women for filling	55.00/each	550.00
10 Numbers	Boys for filling	50.00/each	500.00
L. S	Coir		40.00
5 Numbers	Man for removing after complition	80.00/each	400.00

Total = 3118.00

= Rs. 3118.00/10m

B. Construction of soil cement weir body.

Soil-cement-concrete weir body using 1600 Kg of sand, 120 Kgs cement 120 Kgs of clay for 1 m3 of soil cement concrete mixing , by machine mixing placed in position.

Quantity	Particulars	Rate	Amount (Rs.)
120 kg	Cement	3300/ton	396.00
120 kg	Clay	L.S	15.00
1 m^3	Hire charges of mixer	30/m^3	30.00
2.00	Man	80/each	160.00
1.00	Woman	55/each	77.00
1 m^3	Consolidation by vibratary compactor	55/m^3	55.00

Total = 733.00

= Rs. 733/m^3

C. Gabbion Work

1. Earth work exeavation for sandy soil including in or under water.

Quantity	Particulars	Rate	Amount (Rs.)
0.90	Man	80.00/each	72.00
2.75	Boy	50.00/each	137.50

Total = 209.50

Add 20% for in or under water = 41.90

Total = Rs. 251/10m^3

2. Dry rubble work for Gabbion work sluiced with sand including all cost and conveyance and labour charges

Quantity	Particulars	Rate	Amount (Rs.)
1.05 m^3	Rubble	220.00/m^3	231.00
0.35 Numbers	Mason for rubble work	120.00/each	42.00
0.70	Man	80.00/each	56.00
0.70	Women	55.00/each	38.00

Total = 367.50

= Rs. 368.00/m^3

3. Supplying making 2mm heavy galvanised iron wire net 10 x 12cm spacing.

Quantity	Particulars	Rate	Amount (Rs.)
1 Qtl.	2mm G.I.wire	2900/Qtl.	2900.00
3 Numbers	Black smith for making wire net	120.00/each	360.00
3.50	Man for assisting	80.00/each	280.00

Total = 3540.00

= Rs. 3540/Qtl.

D. Side protection works

1. Earth work Excavation

   Rate same as in (C) = Rs. 251/10m^3

2. Dry rubble work for gabbion work.

   Rate same as in (C) = Rs. 368/m^3

3. Supplying and making 2mm heavy G.I/net

   Rate same as in (C) = Rs . 3540/Qtl.

STUDY OF BHARATHAPUZHA BASIN WITH SPECIAL REFERENCE TO CHECKDAMS

By
PREMRAJ, P.

ABSTRACT OF THE PROJECT REPORT

Submitted in partial fulfilment of the requirement for the degree

Bachelor of Technology in Agricultural Engineering

Faculty of Agricultural Engineering and Technology
Kerala Agricultural University

Department of Irrigation and Drainage Engineering
KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY
TAVANUR - 679 573, MALAPPURAM
KERALA, INDIA

1999

ABSTRACT

Water is prime natural resource, a basic human need and a precious national asset. The planning and management of this resource and its optimal, economical and equitable use are important and urgent. Unlike many northern rivers of the country, none of the state rivers is snow fed, resulting in sharper imbalance between the water availability between summer and monsoon months. Kerala has an average rainfall of 3000mm. Though the rainfall in the state is 2.5 times higher than the national average, the steep topography, extreme uneveness of rainfall in time and space, very short river lengths, unique physiography, geology, soil, vegetation and very high population density have resulted in low capability for utilisation.

Because of the steep topography of Kerala, water flowing through the 44 revers cannot be utilised properly. In Kerala 20% of river water is utilised where as in Tamil Nadu even 90 % of the river water can be utilised. Because of the improper water management most of the wells and rivers are getting dry during summer season. Hence immediate attention should be given for water harvesting.

Bharathapuzha is the second longest river in Kerala originating from Anamali Hills in the Coimbathore district in Tamil Nadu at an elevation of 1964 msl. The characteristics of the basin, flow characteristics and other relevant aspects of the Bharathapuzha basin are studied. Water scarcity during summer season is the main problem of Bharathapuzha which is mainly due to the large gradient. If proper water conservation techniques are adopted, these problems can be solved effectively.

Considering the topographic features, high population density and none availability of waste lands of the state, the most suitable method of water harvesting is the construction of check dams/sub-surface dams. As a part of this, 14 locations were selected which are found to be suitable for the construction of check dams/sub-surface dams. Site selected for this study is at Thrangali Kadavu in Palakkad district. Construction of sub-surface dam in Thrangali Kadavu is suitable, since it can avail water for both irrigation and drinking water schemes, the width of the river is comparatevely less and stiff clay is available at shallow depth.

The sub-surface dam is constructed by using sand-cement-bentonite-clay grout mix in the proportion of

sand	:	1500 kg/cumec
cement	:	60 kg/cumec
bentonite	:	68 kg/cumec
water	:	450 litres/cumec

The dam is protect by gabbion work in the upstream and downstream of the bottom of river. Both the left and right banks of the river is also protected by providing gabbion works for a length of 25m on upstream and downstream upto a height of high flood level.

The study include,

1. General Study of Bharathapuzha basin
2. Monitoring of the existing and post structure ground water profile.
3. Drill holes to find the depth of clay level .
4. Laboratory investigations.
5. Water requirement details.
6. Construction details of subsurface dam.

From the study it is found that this type of checkdams are cheap, economical, eco-friendly and fast method of construction. Hence, this type of dams can be used at various locations in the rivers of Kerala for proper water harvesting; which will help to fulfil our water needs in summer. So, this method of construction should be strongly recommended, promoted and popularised.

For studying the effectiveness of check dam monitoring of the water level in the adjoining wells and water source for irrigation and drinking water schemes is essential. Monitoring of water level is already started.

The saving of Bharathapuzha could well pave the way for saving of the other rivers of Kerala all of which are faced with the same fate.