

Chapter 4

Surveys and investigations

Field surveys and investigations were carried out originally for Punnamedu, Achankovil Kal Ar and Achankovil pumped storage dams at old locations 150 m, 50 m and 80 m upstream of the present sites. These sites were examined with reference to geological considerations and were abandoned in favour of the present sites on the suggestions of Geological survey of India and surveys and investigations were carried out for these present sites.

4.1 Topographical surveys

4.1.1 River

Necessary surveys have been carried out along Pamba Kal Ar for a distance of 11 km upstream of Punnamedu dam. Total 7 Nos. of cross sections were taken along the river at intervals of 50/100 m upto a distance of 500 m upstream of dam axis. On the downstream of the dam site 20 cross sections were taken across the river for 10 km length at 500 m interval. The bed fall of river is around 1 in 35.

Surveys along Achankovil Kal Ar have been carried out for a length of 23 km upstream of Achankovil Kal Ar dam. Total 7 Nos. of cross sections were taken along the river at intervals of 50/100 m upto a distance of 500 m upstream of dam axis. 7 cross sections at interval of 500 m have been taken downstream of dam axis for a length of 3.5 km i.e. upto the Achankovil Kal Ar river's confluence with Achankovil river. The bed fall of river is around 1 in 29.

Necessary surveys of Achankovil River have been carried out along river course for a distance of 11 km upstream of Achankovil pumped storage scheme. Total 4 nos. of cross sections were taken along the river at intervals of 50/100 m for a distance of 300 m upstream of dam axis. Downstream of dam site, 13 cross sections were taken along the river for a length of 6.9 km at 500 m interval.

4.1.2 Reservoir

The reservoir formed across Pamba Kal Ar by the construction of Punnamedu dam will extend about 11 km along Pamba Kal Ar. The Achankovil Kal Ar reservoir extends for 23 km along Achankovil Kal Ar and the reservoir of Achankovil pumped storage scheme will extend for 11 km along Achankovil river and for 3.5 km along Achankovil Kal Ar upto Achankovil Kal Ar reservoir.

The reservoir surveys of all the three reservoirs were carried out by Survey of India. Based on the contour maps supplied by them in the scale of 1:10000 with a contour interval of 25 m, the areas of the reservoirs were computed through the interpolation of contours with 10 m interval. The area of submergence of Punnamedu reservoir at FRL 246.0 m is 440 ha and gross storage capacity is 208 Mm³. The submergence of Achankovil Kal Ar reservoir at FRL 210.0 m extends over an area of 1240.7 ha with a gross storage capacity of 497 Mm³. The reservoir of Achankovil pumped storage scheme has a submergence of 323 ha with a gross storage capacity of 30.6 Mm³.

4.1.3 Head works

Block level survey has been conducted taking dam axis as base line. Further grid lines are aligned perpendicular and parallel to base and block levels are taken at every 50 m extending 500 m on either side of dam axis in case of Punnamedu and Achankovil Kal Ar reservoirs and block levels are taken at 100 m interval for 300 m on either side of dam axis for Achankovil pumped storage scheme. Contour plans of all the three dam sites are prepared in a scale of 1:2000 with a contour interval of 5 m.

The deepest bed level of Punnamedu dam is 115.3 m and Achankovil Kal Ar dam is 66.310 m, while the same for Achankovil pumped storage scheme is 38.485 m.

4.1.4 Plant and Colony Layout

Regular project camps consisting of residential and non-residential buildings are proposed to be built on the left side of the Achankovil Kal Ar dam in blocks of 50 m x 50 m. Grid Surveys have been carried out at two locations in an area of 500 m x 500 m each, for location of colony.

4.1.5 Canal and water conductor system and canal structures

Block levelling was carried out along length of main and branch canals with grid interval of 50 m and cross sections are taken at 500 m interval extending 250 m on either side of centre line of canal. Additional cross sections were also taken, wherever an undulating terrain prevails. Since the main canal is a contour canal, it crosses number of valleys and in order to facilitate crossing of these valleys, cross drainage works like super passages and aqueducts are proposed depending upon site conditions. Single and double lane bridges are provided across the main and branch canal with a minimum headway of 0.75 m above full supply level. Site surveys were carried out at the crossings of minor drainages/roads/channels at a grid interval of 50 m for a length of 100

m upstream and 100 m downstream of the structure extending upto 300 m on either side of centre line of the canal. Grid surveys covering an area of 600 m x 600 m are carried out at 50 m intervals at the crossing of medium streams.

4.1.6 Powerhouse, Switchyard, Surge shaft, Tailrace, etc.

Grid surveys have been carried out at contour interval of 5 m for a block of 500 m x 500 m each for locating power house and switchyard. 18 numbers of cross-sections were taken at 50 m interval for the tailrace of Achankovil Kal Ar powerhouse.

4.1.7 Tunnel, Adits and Penstock

Grid surveys have been conducted at 5 m contour interval for a block of 250 m x 400 m each for the entry and exit points of interconnecting tunnel between Pamba Kal Ar and Achankovil Kal Ar reservoirs. In case of inlet of tunnel on Tamil Nadu side, grid survey was done at 1 m contour interval for a block of 350 m x 350 m. The surveys for the alignment of both the tunnels have been carried out by Survey of India. Separate surveys for alignment of Penstocks were not done, as the area is covered under dam axis survey.

4.1.8 Command area

The culturable command area under the project is 101555 ha. The annual irrigation with 90% irrigation intensity is 91400 ha. The cost of distributaries system is taken as Rs. 13,650/- per ha. The cost of on farm developments is taken as Rs. 3000/- per ha. These costs put together matches well with cost assessed from the command area survey done by NWDA for a sample area of 15,000 ha. The cost of cross drainage and cross masonry works along main canal was estimated based on their hydraulic design.

4.2 Other Surveys

4.2.1 Archaeological Surveys in the Reservoir Area

There is no structure or monument of Archaeological importance in the submergence area.

4.2.2 Communication Surveys

The Punnamedu dam on Pamba Kal Ar can be approached from Konni town located 31.5 km away. The Achankovil Kal Ar dam site is approachable from Alimukku town, 46 km from dam site. The Achankovil pumped storage scheme is connected to Punalur – Pathanamthitta road at a distance of 35 km.

A new road is to be constructed to approach Achankovil Kal Ar dam from Achankovil village and the existing forest roads are to be improved to approach Punnamedu, inlets and outlets of interlinking tunnel.

The nearest railway station to all the dam sites is Punalur. The command area is well served by existing roads.

4.2.3 Drainage Surveys

The command area is drained by major streams like Vaippar, Nichibanadi and other medium streams like Alagar odai, Kamba Ar, Nagalar Ar, Kottamalai Ar, Kal odai, Uppu odai, Solapuram, Kayalkudi, Uppar in addition to other minor drains. As such, the command area may not face a serious drainage problem.

4.2.4 Soil surveys

The Soil Surveys and Land Use Organization of Govt. of Tamil Nadu has already conducted detailed taluk wise soil surveys. The soil classification map of command area has been prepared from the taluk wise soil survey maps collected from the above organization for the taluk falling in the command area.

4.3 Geology, Geotechnical features and Seismicity

The Geological Survey of India was entrusted with the geological investigations of the dam sites. Site inspections were carried out by GSI and based on these and Geotechnical investigations carried out by them earlier for Kerala Electricity Board, the Geological evaluation of the dam sites has been made.

As per the GSI findings, the area comprises of rocks of Archaean complex with intrusives of granites and dolerite dykes.

Geological succession is as follows

1	Recent to sub recent	Soil and alluvium	
2	Recent to Tertiary	Laterite and tuffaceous Kankar	
3	Intrusives	Basic – dolerite dykes. Acidic – Vein Quartz, Pegmatite, granite.	
4	Archaean complex	Garnetiferous biotic Gneiss Hornblende gneiss Leptynites	Magmatitic Gneissic Complex
		Hybrid charnockite gneiss and associated migmatite	Charnockite Group
		Sillimanite gneiss Quartzite	Khondalite group

Charnockite gneiss and its associated rocks are the predominant rock types encountered in these areas.

The Geotechnical evaluation of the project sites based on investigations of GSI is enumerated in the following paras:

a) Punnamedu dam

The GSI has investigated a site 150 m downstream of present location, as proposed earlier by NWDA, and inferred that fresh rock levels are varying from 1 to 2 m in the river bed, about 10 m on the right flank and 14 m on the left flank. The over burden includes soil, scree material and weathered rocks. The saddle which is present across the dam axis on the left flank at +165 m poses a topographical disadvantage for the dam. The GSI has suggested that a kink be given in the axis on the left flank towards upstream about 170 m from centre of river on left flank or alternatively a straight line alignment from upstream point which is about 25° askew to the river flow. The geological conditions at these two sites are expected to be similar. The straight alignment was considered for design purpose, since it involves lesser length of dam.

The slopes of flanks in this alternative alignment are steeper (45°-50°) and bedrock levels are expected to be below 10-14 m at reasonable depths in the flanks. In view of steeper flanks, fresh rock at shallow level and the non-availability of suitable materials at reasonable lead, the GSI has suggested construction of concrete dam instead of composite dam as proposed earlier.

b) Achankovil Kal Ar dam

The NWDA has proposed earlier a dam on Achankovil Kal Ar, 50 m downstream of present location and on verification of the site, the GSI has observed that, while rock exposures are confined to river bed, the flanks and uphill side slopes are covered with soil and boulders. The thickness of overburden is around 10-15 m at lower levels and upto 25 m at higher levels.

Though the geological setup does not vary significantly in and around the proposed axis, the GSI has suggested to shift the dam by about 50 m upstream as the gorge looks comparatively narrower resulting reduction in length. Due to non-availability of earth and rock fill materials nearby, construction of concrete dam instead of rock and earth fill dam was suggested by GSI.

c) Achankovil Pumped storage scheme

The GSI has examined a site 80 m downstream of the present location, which was proposed earlier by NWDA and indicated that while the right flank slope is about 50° at dam axis and upstream, the left flank slope is about 30° at dam axis and 45° at 50 m upstream but the slope angle is shallow (about 30°) towards down stream. The overburden is anticipated to be about 1-2 m on right flank and about 10 m on left flank. Based on the preliminary study, the GSI has suggested a location 80 m upstream of proposed location of NWDA, where the left flank slope is also equally steeper. The suggestions of GSI to shift the site to present location are accepted.

d) Interlinking tunnel inlet

The Punnamedu – Achankovil Kal Ar tunnel inlet is located on the left bank of Chelikkal Ar, a tributary of Pamba Kal Ar. Two sites about 300 m apart were examined by GSI. At one site, rock is exposed at sill level of tunnel but only thick overburden is present on the uphill side for a long distance. At the other site moderately weathered to fresh rock is seen at portal location. Sufficient rock cover to form the portal is expected about 50 m from river edge. The later site was preferred by GSI.

e) Interlinking tunnel outlet

The outlet of interlinking tunnel proposed earlier by NWDA is located on right flank of Muthuvantodu River. At outlet point, only soil and scree material are observed but it is inferred that fresh rock is exposed at around RL 215 m and

sufficient rock cover will be available at a location towards upstream of the present proposed site. Two drill holes one at RL 228 m and another at RL 250 m about 50 m upstream are proposed by GSI to suggest suitable location for locating portal.

f) Achankovil Kal Ar - Tamil Nadu tunnel inlet

The tunnel inlet proposed by NWDA earlier is located on a tributary on the left flank of Achankovil Kal Ar about 4 km east of Pulikkayam. Huge boulders of granite gneiss and charnockite of varying sizes are piled up at the confluence of stream with river. Due to problems anticipated with the movement of boulders by floods, an alternative site about 450 m downstream was examined by GSI. Massive charnockite gneiss is exposed about RL +200 m and above. Overburden of 2-5 m is inferred on the slopes.

g) Achankovil Kal Ar - Tamil Nadu tunnel outlet

The tunnel outlet proposed by NWDA earlier falls in the riverbed of Mundalar. The site is in river alluvium and rock level is expected to be more than 15 m below ground level. So the entire tunnel outlet portal will have to be formed only in overburden. An alternative location about 500 m north-east of the proposed tunnel outlet was suggested by GSI where massive charnockite is exposed.

h) Bay

A 1.5 km long bay was proposed by NWDA earlier at the exit of tunnel to act as energy dissipation device. Charnockite exposures are noticed in the initial reaches and the rest is covered with soil and alluvium. With the shifting of tunnel exit, the alignment of bay needed to be shifted. The GSI has suggested shifting of bay alignment further east so that stream crossings can be restricted which can pose construction and maintenance problems. However, instead of bay, only an energy dissipation device has been provided at the exit of tunnel in the present proposal.

4.4 Foundation Investigation

The GSI has suggested drilling of three diamond drill holes along Punnamedu dam axis one in the river bed and two at the middle flanks and five bore holes along Achankovil Kal Ar dam axis one in river bed, one each on flanks at +215 m RL and one each on flanks at middle levels to determine bed rock profile and other characteristics. A set of three drill holes one in river bed and one

each on flanks at +65 m RL are proposed along Achankovil Pumped storage dam axis.

Two drill holes one at RL 228 m and other at RL 250 m about 50 m towards upstream of Interlinking tunnel outlet are proposed.

A drill hole at 500 m upstream of Achankovil Kal Ar - Tamil Nadu tunnel outlet was recommended by GSI to assess bedrock level for tunnel outlet.

The detailed classification of various soils met with along the entire length of the canal alignment was done by excavating with manual auger holes drilled at 6 km interval upto soft rock level. In addition, auger holes were drilled at C.D. works and C.M. works to ascertain soft/hard rock profile and general characteristics of the soil. A total of 66 Nos. of samples (62 disturbed and 4 undisturbed) were collected. Out of this, 17 disturbed and 4 undisturbed samples were tested at Soil Mechanics and Research Division of Tamil Nadu Public Works Department at Madras. Routine and special tests were conducted to determine the suitability of soils in laying embankments.

Soil classification:

The soils at the above location are grouped according to Indian standard soil classification. Four types of soil groups are identified along the canal alignment. The brief description of soils are given below:

Group – I: These soils classified as sand silt mixture and are denoted in short as 'SM'. These soils are poorly grained sandy materials, generally rough in dry weather and fairly stable in wet weather. They can be compacted with tamping or smooth faced rollers and are good to excellent for foundations. This group is identified in isolated reaches near R.D 6.865 km and 34.237 km. Seepage control measures are essential for these type of soils.

Group – II: These soils are classified as sand and clay mixture and are denoted in short as 'SC'. These soils are fine grained having low plasticity, consisting predominantly of silt or silt loam, moderate to small amount of coarse material with no appreciable amount of sticky colloidal clay. These soils vary widely in texture, composition and range from the sandy loam to silt and clay loams. It makes good foundations when dry but stability is lost when wet. These soils red to dark brown in colour exist predominantly along the alignment from 6.5 km to 47.00 km.

Group – III: These soils are classified as clay of medium plasticity and are denoted in short as 'CI'. This group of soils contain poorly graded soils and an appreciable percentage of materials such as mica and diatones which form highly elastic sub grades, which appreciably rebound on removal of load even when dry and are very low and doubtful in stability and difficult to compact. These soils are met to the natural drains. These soils do not require any special seepage control measures.

Group – IV: These soils classified as clay of low plasticity and are denoted in short as 'CL'. This group of soils are composed predominantly of highly plastic colloidal clay with moderate to negligible amounts of coarse material. In the stiff soft plastic state, they absorb water only when manipulated and become fluid. They can be compacted to relatively high densities by use of heavy rollers and have good capacity when compacted to maximum practical density and rebound very little on removal of load. These soils do not require any special seepage control measures. This group is identified near to the Western Ghats in the initial reaches of canal from 0 to 6.5 kms and 7.75 to 8.25 kms. A summary of test results of soil samples tested is as follows:

Summary of Results of Soil Samples

Sl. No.	Properties	Soil samples tested for		
		Side slope	Embankments	CD/CM works
1.	Optimum moisture content	10-18%	12-16%	10-16%
2.	Maximum dry Density	1790-2198 Kg/m ³	1763-1990 Kg/m ³	1906-2138 Kg/m ³
3.	Cohesive strength	1500-3500 Kg/m ²	1000-2750 Kg/m ²	1000-3600 Kg/m ²
4.	Angle of friction	15-30 ^o	19-32 ^o	9-38 ^o
5.	Co-efficient of permeability	0.513-85.6x10 ⁻⁶ cm/sec	-	0.025-29.7x10 ⁻⁶ cm/sec
6.	Specific gravity	2.38-2.70	-	2.46-2.60

However, detailed soil exploration and testing of samples would have to be done to firm up final design of the CD/CM works and canal.

4.5 Construction Material Investigations

Necessary borrow area surveys have been carried out for construction materials such as stone, sand etc.

4.5.1 Sand

Sand is in scarcity in the Pamba and Achankovil basins and it is proposed to substitute quarry dust for the sand. However, 5 sand quarries are identified in Tamil Nadu area that can be used for canal construction. It is expected that about $7.4 \times 10^5 \text{ m}^3$ of sand will be available from these quarries. The average lead is around 15 km.

4.5.2 Rocks and Aggregates

26 quarries have been identified in the vicinity of head works in Kerala that can yield $232 \times 10^6 \text{ m}^3$ of stone. Six quarries are identified in the command area in Tamil Nadu with the yield of $2.24 \times 10^8 \text{ m}^3$ of rubble. The average lead is around 10 km.

4.5.3 Bricks

Brick manufacturing units are not available in the near vicinity of the project area at head work side. Bricks of good quality are reported to be available in the vicinity of the command area side of the project.

4.5.4 Cement and Steel

The cement and steel will be received from Punalur railway station and will be transported to stores/stock yards near to site of work. The average lead by road for the above material is about 45 to 80 km.

4.5.5. Any Other Materials

In respect of canal structures scattered all along the canal, the construction materials like stone and broken metal will be obtained from the identified quarries indicated in Para 4.5.2. Sand will be obtained from stream beds of Hanuman Nadi, Chittar, cement and steel will be transported by rail from Shenkottai where they will be conveyed to the site with a lead not more than 2 km.

4.6 Hydrological and Meteorological Investigations

a) The CWC is conducting hydrological observations using current meter at Thumpamon site on Achankovil river for which discharge data is available from 1978-79 onwards. In addition, discharge data at three more sites viz., Tura, Pantalam and Kollakadavu maintained by Kerala Public Works Department are also available. While the data of Kollakadavu and Pantalam sites are available from 1970-71 onwards, the data of Tura site is available for a short period from 1978-79 to 1981-82. The discharge data of CWC site was considered for hydrological studies as the observations are made by using current meter. There are two G&D sites viz., Erapuzha and Kurudamannil on Pamba River maintained by Public Works Department of Kerala. The sites are located in the middle and lower reaches of the basin and there are no G&D sites in the vicinity of Punnamedu dam. As such the rainfall – runoff relationship developed for Thumpamon site has been considered for estimation of yields at Punnamedu dam

b) Monthly rainfall data is available for 9 raingauge stations in and around the catchment upto Thumpamon site. The rainfall data of these stations during the period 1978-79 to 1984-85 has been considered in the study. There are no raingauge stations within the catchment upto Punnamedu dam. The data of nearest Muzhiar raingauge station was considered in estimating yields. There are no raingauge stations in the combined catchment upto Achankovil pumped scheme. Rainfall data of two raingauge stations lying outside the catchment was considered for estimation of yields.

c) Sediment sampling and analysis is being done by CWC at Thumpamon site and the sediment data at this site for the period 1981-82 to 1984-85 is given in the Chapter on “Reservoir”.

d) Pan evaporation and other meteorological data in relation to command area is available for Madurai IMD and Kavalur meteorological stations.