Chapter 5
Hydrology

5.1 Hydrological inputs to the project planning

The hydrological inputs required in planning a project are rainfall, observed discharge, upstream utilisations, downstream requirements, evaporation and sediment data. The rainfall and observed discharge data alongwith upstream utilisations are required for establishing rainfall-runoff relationship at the desired point and to compute gross yields available upto that point from the upstream catchment. The downstream committed requirements are needed to establish the net yields available at the project site for its utilisation. The net inflows available at the project site alongwith the project's irrigation/power and other requirements, downstream committed uses and evaporation data are made use of in simulation studies. While the sediment data is required to work out sediment distribution and for fixation of dead storage, full reservoir level etc., the probable maximum storm data is required for establishing design flood at the project site, which in turn is used in flood routing studies for fixation of spillway length, maximum water level and maximum flow over the spillway.

The time unit adopted for establishment of rainfall-runoff relationship and simulation studies is month wise.

5.1.1 Availability of Hydrological Data

There is a Gauge and discharge site, being maintained by the Central Water Commission at Thumpamon on Achankovil River downstream of the proposed Achankovil dam site. The flow data at this station is available for the period from 1978-79 to 1990-91. The flow data of these 13 years together with the concurrent rainfall data for the 9 raingauge stations (4 of IMD, 2 of KSEB and 3 of Private Estates) in and around Achankovil basin upto to Thumpamon G&D site have been used for deriving the rainfall-runoff relationship at Thumpamon. The rainfall data of stations maintained by IMD and KSEB is observed by means of automatic and ordinary rain gauges and the consistency of the data is checked by plotting Double Mass Curve. The data of Private Estates was compared with the adjacent stations of IMD and found to be consistent. There is no G&D site on Pamba Kal Ar, tributary of Pamba River. In the absence of observed flow data for Pamba Kal Ar, the flow data observed for Achankovil river is utilised for working out yield of Pamba Kal Ar

river at dam site as the catchments of Punnamedu dam is hydrologically and meteorologically similar to the catchment of Achankovil basin.

5.2 Yield studies at dam sites

i) Achankvoil dam

Two raingauge stations viz. Anatodu and Ambanad estate are influencing the combined catchment of Achankovil reservoir (inclusive of Achankovil Kal Ar catchment). The weighted average monsoon rainfall upto Achankovil reservoir has been worked out for the period 1970-71 to 1990-91 taking average of rainfalls of the above two stations.

The monsoon gross yields at Achankovil reservoir for the period form 1970-71 to 1990-91 are computed by substituting weighted average monsoon rainfall values in the best-fit equation developed for the Thumpamon site. The non-monsoon yield is worked out as a percentage of monsoon gross yield and added to the monsoon yield to arrive at gross annual yields. From the annual yields thus generated, the 75% and 50% dependable annual yields for the combined catchment upto Achankovil reservoir are found to be 453 Mm^3 and 486 Mm^3 respectively. As the raingauge stations influencing the catchments of Achankovil Kal Ar reservoir and Achankovil reservoir are the same, the monsoon yield at these reservoir sites were worked out on proportionate area basis from the yield developed for the combined catchment upto Achankovil dam. The 75% and 50% dependable annual yield for the net catchment of Achankovil dam site works out to 195 and 210 Mm^3 respectively.

ii) Achankovil Kal Ar Dam

The annual yield series of the independent catchment of Achankovil Kal Ar reservoir was assessed on proportionate area basis from the yield of combined catchment upto Achankovil reservoirs. The 75% and 50% dependable yield at Achankovil Kal Ar dam site computed as explained above, works out to 255 and 275 Mm^3 respectively.

iii) Punnamedu Dam

One raingauge station, viz, Muzhiar only is influencing the catchment upto Punnamedu reservoir. The rainfall data at this station is available for the period from 1970-71 to 1990-91.

The monsoon gross yields at Punnamedu reservoir for the period 1970-71 to 1990-91 are computed by substituting the monsoon rainfall in the best-fit equation developed at Thumpamon site. The non-monsoon yield is worked

out as a percentage of monsoon yield, based on gross monsoon and non-monsoon yields at Thumpamon site. These non-monsoon yields are added to gross monsoon yields of Punnamedu reservoir to arrive at gross annual yields. From the gross annual yield series thus generated, the 75% and 50% dependable yields are found to be 259 Mm^3 and 311 Mm^3.

5.3 Crop water requirement

The crop water requirement for the crops proposed in the command is worked out on climatological approach and ten daily water requirements are computed. Transmission losses in the canal are considered at the rate of 0.6 M^3 /sec per Mm^2 of wetted area. These losses are added to the ten daily net crop water requirements to arrive at gross requirement. The details of computations of crop water requirement are given in Chapter on "Irrigation Planning and Command Area Development".

5.4 Evaporation losses

The evaporation losses in the reservoirs are taken as per evaporation losses observed in Idukki reservoir in Periyar basin adjacent to Pamba basin. There are no climatological stations observing evaporation data in the catchments of the proposed dam sites. It was seen that the total losses on account of evaporation from the reservoirs are only a fraction of the total yield available at these reservoir site and is hence insignificant. Hence evaporation losses are separately not considered for simulation studies. However the total annual evaporation losses for all the three reservoirs put together assessed on the basis of evaporation losses observed in the existing Idukki reservoir works out to 10 Mm^3.

5.5 Sediment and its effect on storage

The studies on sediment and its effect on storage are furnished in Chapter on reservoir. According to these studies, the accumulation of silt in 50 years is 380.4 ham, 532.5 ham and 313 ham at Punnamedu, Achankovil Kal Ar and Achankovil reservoir respectively. The live storage capacity of the reservoirs after 50 years of sedimentation is 114.6 Mm^3, 184.6 Mm^3 and 26.0 Mm^3 at Punnamedu, Achankovil Kal Ar and Achankovil reservoirs. The gross storage capacity after 50 years of sedimentation is 204.2 Mm^3, 491.6 Mm^3 and 27.4 Mm^3 at the respective reservoirs. These revised capacities are considered for simulation studies.

5.6 Upstream utilisation

There are few existing, ongoing or proposed projects in Pamba basin, Achankovil basin and Vaippar basin. However, there are no major or medium projects existing upstream of the proposed dam sites.

5.7 Water Balance

The general water resources position of the Pamba basin, Achankovil basin and Vaippar basin showing the details of annual irrigation, imports, exports, water requirements for various uses and the water balance position of these basins are given below:

Basin wise water resources situation

Basin	Annual irrigation	Import	Export	Total water requirement	Water balance at75% 50%	
	1000 ha	Mm^3	Mm^3	Mm^3	Mm^3	Mm^3
Pamba	124.1	374	774	1721	1612	2255
Achankovil	62.4	796	374	924	1515	1794
Vaippar	118.4	-	-	1610	- 922	- 874

5.8 Simulation

Simulation studies are carried for the link for the period from 1978-79 to 1990-91 considering the net monthly inflows computed at the three dam sites. The simulation studies have been carried out on monthly basis. The supply of waters from Punnamedu is made to Achankovil Kal Ar through an interconnecting tunnel and the waters from Achankovil Kal Ar are diverted for irrigation through a tunnel from Achankovil Kal Ar, which terminates into a gravity canal on the eastern side of Western Ghats. The Achankovil reservoir is used as pumped storage dam to pump the available waters at Achankovil reservoir to Achankovil Kal Ar reservoir during the monsoon to build up storages there. A quantity of 10 M^3 will be released per day from Achankovil Kal Ar reservoir to Achankovil reservoir through out the year during six hours peak period for power generation and the same quantity is pumped back on same day in the remaining 16 hours. The Achankovil reservoir also regulates the mandatory downstream releases of 120 Mm^3 per annum envisaged from Achankovil river for combating salinity intrusion and the drinking water supply. The downstream releases required at Achankovil reservoir are supplemented from Achankovil Kal Ar, if necessary. A quantum of 30 Mm^3 a year will be released from Punnamedu to combat salinity intrusion and for drinking water

supply. The simulation studies are carried out considering the storage capacities of the reservoirs after 50 years sedimentation.

5.8.1 Period of simulation and operational policies used

The inflow series for the period 1978-79 to 1990-91 with each year having 12 periods was used for simulation studies. The continuity equation and operation policy for releases used for the three reservoirs are as follows:

a) Punnamedu Reservoir

The continuity equation adopted at this reservoir is

$$S_{t+1} = S_t + I_t - Q_t - D_t$$

Where

S_{t+1} = Storage at the end of the 't'th period
S_t = Storage at the beginning of the 't'th period
I_t = Inflows during the 't'th period
Q_t = Diverted flows from Punnamedu to Achankovil Kal Ar reservoir during the 't'th period.
D_t = Mandatory downstream releases during the 't'th period for ecological purposes and drinking water supply.

The operation policy for release of water at Punnamedu reservoir is to accord priority to mandatory downstream releases. Mandatory releases amounting to 30 Mm^3 are proposed during the period from October to May.

b) Achankovil Reservoir

The continuity equation used for the reservoir is

$$S_{t+1} = S_t + I_t + R_t - D_t - Q_t$$

Where

S_{t+1} = Storage at the end of the 't'th period
S_t = Storage at the beginning of the 't'th period
I_t = Inflows during the 't'th period
R_t = Flows needed from Achankovil Kal Ar for supplementation to downstream releases during the 't'th period
D_t = Mandatory downstream releases during the 't'th period

Q_t = Diverted flows from Achankovil to Achankovil Kal Ar reservoir during the 't'th period.

The operation policy at Achankovil reservoir is to accord priority to mandatory downstream releases needed to combat salinity intrusion downstream of the river. The downstream releases amounting to total quantum of 120 Mm^3 would be during the period from October to May. From June to September, the inflows at Achankovil reservoir are pumped to Achankovil Kal Ar reservoir to build up storages.

c) Achankovil Kal Ar Reservoir

The continuity equation at this reservoir is

$$S_{t+1} = S_t + I_t + R_{1t} + R_{2t} - Q_{1t} - Q_{2t}$$

Where

S_{t+1} = Storage at the end of the 't'th period
S_t = Storage at the beginning of the 't'th period
I_t = Inflows during the 't'th period
R_{1t} = Diverted flows from Punnamedu to Achankovil Kal Ar reservoir during the 't'th Period
R_{2t} = Diverted flows from Achankovil to Achankovil Kal Ar reservoir during the 't'th Period
Q_{1t} = Irrigation requirements during the 't'th period
Q_{2t} = Diverted flows from Achankovil Kal Ar reservoir to Achankovil for supplementation to downstream releases during the 't'th period.

The operation policy at Achankovil Kal Ar reservoir is such that during the period from June to September, the irrigation demands are met depending on the reservoir storages. From October to May, priority is given to flows needed for supplementing the storages at Achankovil to meet downstream releases. The irrigation demands will be met after supplementation for d/s releases only. A quantity of 10 Mm^3 is released all round the year for 6 hours a day to Achankovil dam to generate power. This quantity is pumped back to the Achankovil Kal Ar reservoir during the remaining 16 hours of the day.

5.8.2 Irrigation Demands

Monthly requirements for irrigation from December to May are considered in the simulation studies.

5.8.3 Performance testing

The simulation studies indicate that the project is successful in delivering 634.76 Mm^3 of water for irrigation in 85% of year with 95% rate of success in meeting the committed downstream releases. The diverted quantity of 634.76 Mm^3 less the transmission losses is envisaged to irrigate an area of 91400 ha with a delta of 0.694 m.

5.9 Effect of project on Hydrologic Regime

5.9.1 Effect on Vembanad Lake

The flood inflow into the Vembanad lake will be moderated, while the lean period flows will be augmented through the proposed d/s releases. The quantum of water proposed to be transferred is very small as compared to the normal variation in the inflows into the lake and the impact on the hydrologic regime of the lake will be minimal. Pollution in the lake will be reduced as augmentation of lean period flow from the proposed project will help in flushing the polluted waters.

5.9.2 Changes in Hydrologic Regime

The mandatory downstream releases of 1.43 m^3/sec (30 Mm^3 for 8 months in a year) from Punnamedu dam and 5.72 M^3/sec (120 Mm^3 for 8 months in a year) from Achankovil dam during lean season from October to May would improve the low flow of the Pamba Kal Ar and Achankovil rivers besides improving the much needed quality of Vembanad lake.

The peak floods in Pamba and Achankovil rivers would get moderated due to the proposed diversion and flood absorption capacity between FRL and MWL.

5.10 Design Flood

5.10.1 Design flood for safety of structure

Design flood (Probable Maximum Flood) was estimated from synthetic unit graphs, as observed data of the historical flood and corresponding rainfall data were not available.

The 24 hrs probable maximum precipitation (PMP) values have been obtained from IMD. These values have been increased by 15% to represent 24 hrs storm values for obtaining the maximum probable storm. These 24 hour PMP values have been converted to Point PMP values of the required duration by extrapolating curves for Konkan and Malabar Coast Sub-Zones 5(a) & 5(b) given in the CWC publication, “Flood estimation report for west coast region

Konkan and Malabar Coasts sub-zones 5(a) & 5 (b)". These point rainfall values were then used to obtain the aerial rainfall values of the required duration, using the aerial to Point rainfall ratio (percentage) v/s Area Curve. The duration of Probable Maximum Storm (PMS) has been taken as the base period of the unit hydrographs adjusted to next 24 hrs. Cumulative hourly precipitation was then derived using distribution co-efficient obtained from the Mean Average time distribution curves of storms of various durations given in the CWC publication. The incremental hourly precipitation was then rearranged on the unit graph ordinates to derive the probable maximum storms.

Initial loss was assumed to be 10 mm and loss rate was taken as 1.9 mm/hr. Design base flow was taken as 0.15 Mm^3/Km^2. of the catchment area as per the CWC report.

The probable maximum flood for Punnamedu, Achankovil Kal Ar and Achankovil reservoirs are 2738.55 m^3/sec, 1910.45 m^3/sec and 3339.72 m^3/sec respectively.

5.10.2 Determination of outlet levels

Sediment calculations were done assuming a silt rate of 5 ham /100 Km^2/year. The trap efficiencies of reservoirs have been worked out as per Brunes curve. Bed load has been assumed as 15% of the suspended load. The sediment accumulation in 100 years at Punnamedu, Achankovil Kal Ar and Achankovil reservoirs comes to 760.7 ham, 1065 ham and 625 ham with corresponding new zero elevations of 116.697 m, 69.952 m and 43.101 m respectively. However the outlet levels have been fixed keeping in view the levels at which the water is to be transferred. Accordingly, the sill level of interconnecting tunnel between Punnamedu and Achankovil Kal Ar is kept at +211.25 m and sill level of tunnel taking off from Achankovil Kal Ar is kept at +189.80 m. The minimum draw down levels for diversion have been considered at +212.70 m and +192.18 m at Punnamedu and Achankovil Kal Ar reservoirs respectively. The area capacity curves of the three dams have been modified based on sediment accumulation in 50 years. The storage capacities used in simulation studies are based on these area capacity curves.