Chapter - 5
Hydrology and Water Resources

5.1 Methodology adopted for working out water balance

The methodology adopted for working out water balance is discussed in the following paragraphs.

5.1.1 Surface water availability

There are twelve raingauge stations located in and around the Damanganga basin. The rainfall data of these raingauge stations have been collected. The period of availability of rainfall data at these stations varies and in most of cases the data are available for short duration. The long term data for such stations were developed by generating long term series with the help of the long term data of adjacent rain gauge station by statistical methods. The weighted mean monsoon rainfall for the catchment have been estimated by Thiessen polygon method for the period 1901-02 to 1997-98.

The gauge and discharge data of river Damanganga at Vapi G & D site as available in the basin were collected. The data on the existing surface water utilisations of all the irrigation projects upstream of the G&D site have been considered in this study. Regeneration from the existing major projects has been computed at the rate of 10% of their net utilisations. The gross monsoon yields upto Vapi G&D site have been worked out by adding the observed flows, the upstream utilisations and evaporation losses of the reservoirs and deducting the regeneration flows.

Using the gross monsoon yields and the corresponding weighted mean monsoon rainfall, rainfall-runoff relationships have been developed by regression analysis. Considering the best fit equation, the monsoon yield series have been generated. From the data of the non-monsoon observed river flows and the corresponding monsoon virgin flows, the average percentage of non-monsoon flows has been worked out. Adopting this percentage, the non-monsoon yields have been worked out. The monsoon and non-monsoon yields were added to arrive at the gross annual yield series, from which the 75% and 50% dependable gross annual yields have been obtained.

5.1.2 Surface water requirement

The water requirements for various uses viz. domestic, irrigation, industry, hydropower generation, environmental & ecological needs and salinity control have been determined as follows.

5.1.2.1 Domestic uses

The requirement of water for domestic needs in the urban and rural areas as well as for the livestock population has been assessed by projecting the rural, urban and livestock population of the basin to 2050 AD and considering the per capita daily water requirement for the rural and the urban population as 70 litres and 200 litres respectively and that for the livestock population as 50 litres as per the guidelines of the TAC.

The medium variant growth rates indicated in the U.N. Publication "World Population Prospects-1994, Revised" have been considered as annual compound growth rates for

the projections of total population in 1991 AD upto 2050 AD. The percentage of urban population to total population has not been specified in the said U.N. publication. Therefore, the percentage of urban population to total population as given in the previous U.N. Publication 1992 (revision) for the period from 1990 to 2025 AD have been used and projected further upto 2050 AD by regression analysis between the year and percentage of urban population in 2050 AD works out to 66% of total population in 2050 AD. The livestock population for the year 2050 AD was estimated by projecting the latest available livestock population adopting growth rate of 1%.

5.1.2.2 Irrigation uses

Details of the gross command area, culturable command area, designed annual irrigation and designed annual utilisation for the existing, ongoing and future projects were collected and tabulated separately for major and medium projects. The gross command area and culturable command area figures are not available in case of minor schemes and as such, the designed annual irrigation and utilisation only were collected. Water use in the existing and ongoing projects were kept undisturbed. Water use in respect of identified future major, medium and minor projects was estimated considering weighted average delta determined on climatological approach

5.1.2.3 Industrial needs

Actual data on the existing, ongoing and future industries and their water requirement are not available. As such the industrial water requirement has been assumed to be of the same order as the total domestic water requirement and is proposed to be met from surface water resources.

5.1.2.4 Evaporation loss

Evaporation losses in the reservoirs proposed for hydropower generation were assumed as 20% of utilisable water and provison was made for this consumptive use.

5.1.2.5 Environmental and ecological needs

10% of average lean season natural flows has been considered for the environmental & ecological needs.

5.1.2.6 Salinity control

A lumpsum provision of 10% of the 75% dependable yield has been earmarked for preventing salinity ingress in the river near the estuary.

5.1.2.7 Regeneration

The quantum of return flows as regeneration from surface water use was considered as (a) 10% of the net water utilised/to be utilised for irrigation from all the existing, ongoing and identified future major and medium projects (excluding evaporation losses at the rate of 10% for major projects and 20% for medium projects from reservoirs) and (b) 80% of the domestic and industrial water use to be met from surface water sources.

5.1.3 Ground water

The ground water potential and the existing ground water utilisation in the basin were assessed on proportionate area basis from the districtwise ground water statistics compiled by Central Ground water Board in its publication, "Ground Water Resources and Irrigation Potential of India, 1995".

5.2 Surface water balance

The surface water balance studies of the Damanganga river basin have been carried out by NWDA using the above methodology. The position of the water availability, utilisation and balance as indicated in the water balance studies of Damanganga basin and catchment areas of Damanganga basin upto Bhugad and Khargihill dam sites are given in Table 5.1.

Table 5.1
Water balance in the Damanganga basin and at its diversion sites

Unit : Mm^3

Sl. No.	Basin/ Diver-sion site	Catch-ment area (Sq. km)	Gross Annual yield at		Imp-ort	Exp-ort	In basin water require-ment	Rege-nerat-ion	Water balance	
			75% Dep.	50% Dep.					75% Dep.	50% Dep.
1.	Daman-ganga basin	2262	2346	3134	-	357	898	165	1256	2044
2.	Daman-ganga basin upto Bhugad dam site	729	652	883	-	-	182	31	501	732
3.	Daman-ganga basin upto Khargi-hill dam site	710	870	1121	-	-	230	39	679	930

5.3 Water availability at reservoirs

It is proposed to transfer the surplus water available at the two proposed reservoir sites viz. Bhugad and Khargihill to river Pinjal upstream of the proposed Pinjal dam through tunnels. The water balance studies at these two sites estimated the availability of total surplus water as 1180 Mm^3 and 1662 Mm^3 at 75% and 50% dependabilities respectively. This estimate was based on the unregulated annual river flows. Monthly distribution of inflows and requirement and regulatory effect of reservoirs were not considered for estimation of surplus. With their regulatory effect the reservoirs influence the reliability of yield. Therefore, reliability of an estimated natural yield can be increased by considering reservoirs in position. Alternatively, for the same reliability of supplies, the quantity of yield available would be more with the reservoirs in position. With this in

view, simulation studies were carried out for each of the reservoirs. The parameters involved in the studies include monthly inflows into the reservoirs, demands, evaporation losses, elevation, area-capacity relationship of the reservoirs after 50 years sedimentation etc. Most of these parameters including fixation of levels of the reservoirs has been discussed in chapter-7 on "Reservoirs". The inflows and the simulation results in form of yield available from the reservoirs are discussed in the following paragraphs.

5.3.1 Inflows

There are two G&D sites viz Nani Palsan and Ojharkheda maintained by CWC and located just downstream of the proposed Bhugad and Khargihill dam sites respectively. The Nani Palsan and Ojharkheda G&D sites were established in the year 1984 and 1974 respectively. However, the G&D data at these sites has been made available by CWC for the period of 6 years only i.e. from 1991-92 to 1996-97 as the remaining data is inconsistent. Besides, Madhuban reservoir inflow data is also available for a period of 14 years. The flows at the proposed Bhugad and Khargihill dam sites have been estimated in proportion to the catchment area of the proposed dam sites/Madhuban dam.

5.3.2 Net yields available for diversion

The net annual yields likely to be available from reservoirs at 100% dependbility as per simulation studies are given in Table-5.2.

Table 5.2
Net annual yield from reservoirs at 100% dependability

Unit : Mm^3

Sl.No.	Reservoir	Net annual yield for diversion
1	Bhugad	287
2	Khargihill	290
	Total	577

It can be seen from the Table 5.3 that a total quantity of 577 Mm^3 of water is available annually at 100% dependability.

5.4 Design flood

In order to optimally design the spillway and energy dissipation structures, studies to estimate the design flood have been carried out for each of the dam sites.

The design flood was estimated from synthetic unit hydrographs using the physiographical characteristics and from the observed G&D data of the historical floods. The 24 hour probable maximum precipitation (PMP) has been obtained from IMD. These values have been increased by 15% to represent 24 hour storm values for obtaining the probable maximum storm (PMS). These 24 hour PMP values have been converted into point PMP values of the required durations by extrapolating from curves for Konkan and Malabar coast sub-zones 5(a) & 5(b) in the CWC publication "Flood estimation report for west coast region Konkan and Malabar coasts sub-zones 5(a) & 5(b)". This 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. The duration of PMS has been taken as the base period of the unit hydrographs adjusted to the next 24 hours. Cummulative hourly precipitation was then derived using distribution co-efficients 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 hydrograph ordinates to derive the probable maximum storms.

Initial loss was assumed to be 2 mm and the loss rate was taken as 2.3 mm/hr. Design base flow was taken as 0.15 cumec/sq km of the catchment area as per the CWC report.

The final results of the design flood studies of the two reservoirs of the link project are furnished in Table 5.4 below.

Table 5.4
Design flood for the reservoirs

Reservoir	**Catchment area (sq km)**	**PMF obtained from synthetic unit hydrograph (Cumecs)**
Bhugad	729	3789.60
Khargihill	710	4128.70

5.5 Quality of Water

The quality of water is good and fit for drinking purpose with conventional treatment. There has been no significant pollution of the river by dumping of sewage and other waste materials from the villages and towns in the river reaches.