total reservoir capacity of 1.05 billion $m^3$ and an installed capacity of 1.5 million kW. A great deal of observed data on large storms are available for this watershed. Kunming Survey and the Design Institute derived PMP for the project using the combination model method in the 1980s (Wang G., 1999).

#### 7.5.5.1.1 *Basin profile*

The above-dam-site watershed area is 114 500 $km^2$ in Manwan and the river is 1 575 km long. In the north–south direction, the basin is long and narrow and tapers in from the north to the south. The latitude difference is about 9.5°. It spans two climate zones.

The part of the basin north of the Liutongjiang River (with a watershed area of 83 000 $km^2$) is high (with an average elevation of 4 510 m) and the climate belongs to the Qinghai-Tibet Plateau. This part is affected mainly by the westerly-belt weather system, and the weather systems that cause precipitations are mainly westerly troughs and shearing vorticities. Precipitation magnitudes are usually small with low intensities. The spatio-temporal distribution does not change much.

The reach between the Liutongjiang River and the dam site in Manwan (with a watershed area of 31 500 $km^2$) is characterized by a *puna* (high, dry, cold plateau) and a subtropical transitional climate. With a wide range of altitudes, the reach is in the famous Hengduan Mountain region (with an average watershed elevation of 2 520 m), which features multi-layer climates and an observed maximum 1-day precipitation of 163.7 mm. As a result, weather systems of storms in the region mainly include shearing, low troughs, cold fronts, low vortexes, Bay of Bengal monsoon depressions, Bay of Bengal storms and equatorial convergence zones. Moistures come from the Bay of Bengal in the Indian Ocean. In rainy seasons, southwest monsoon circulations are the main moisture transportation currents.

#### 7.5.5.1.2 *Determination of PMP key characteristics*

According to an analysis of observed and surveyed data on storm floods in the watershed, in combination with project requirements, PMP for the Manwan project should have key characteristics as listed in Table 7.6.

#### 7.5.5.1.3 *Storm combination*

Using the similar process substitution method of combination, a storm that occurred in late August 1966 was selected as the typical year. Its storm process and the corresponding synoptic situation are shown in Table 7.7. Under the principle of similar process substitution, the storm process on 22–24 July 1955 was used to substitute the one on 25–27 August 1966; the storm process on 24–26 July 1972 was used to substitute the one on 28–30 August 1966. Information on each year's storms is shown in Table 7.8. The combined 10-day areal mean rainfall was 177.1 m.

#### 7.5.5.1.4 *Analysis on rationality of the combination model*

According to the information in Tables 7.7 and 7.8, the combined and substituted storms complied with the principles of similar process substitution and key characteristics of PMP listed in Table 7.6.

In addition, according to a typical-year 10-day 500 hPa average circulation map and a combined storm 10-day 500 hPa average circulation map (not

**Table 7.6. Key characteristics of PMP for the Manwan project**

| *Item* | | *Characteristics* |
|---|---|---|
| Atmospheric circulation type | | Asian-Europe two-ridge and one-trough type (the west of Baikal Lake is a wide trough area) |
| The storm weather system | | Shearing vorticity and monsoon depression |
| Scope of rain field within the basin | | Widespread precipitation within the basin |
| Location of main rain field | | The middle reach between the Liutongjiang River and the Jiajiuhe River |
| Precipitation duration | Continuous precipitation | 10 days |
| | Areal rainfall ≥ 20 mm | Over 5 days |
| Storm temporal distribution type | | Triple peaks in a saddle-like shape with the main peak ahead |
| Storm occurrence period | | July–August |