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OF THE PEOPLE'S REPUBLIC OF CHINA
中华人民共和国能源行业标准

P NB/T 10233-2019
Replace DL/T 5431-2009

Code for Hydrologic Design of Hydropower Projects

水电工程水文设计规范

(征求意见稿)

Issued on November 4, 2019 Implemented on May 1, 2020

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Chief Development Department: China Renewable Energy Engineering Institute
Approval Department: National Energy Administration of the People's Republic of China
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Introduction

This English version is one of China's energy sector standard series in English. Its translation was organized by China Renewable Energy Engineering Institute authorized by National Energy Administration of the People's Republic of China in compliance with relevant procedures and stipulations. This English version was issued by National Energy Administration of the People's Republic of China in Announcement [20xx] No. xx dated xx, 20xx.

The version was translated from the Chinese Standard NB/T 10233-2019, *Code for Hydrologic Design of Hydropower Projects*, published by China Water & Power Press. In the event of any discrepancy in the implementation, the Chinese version shall prevail.

Special thanks to the staff from the relevant standard development organization and those who have provided generous assistance in the translation and review process.

For further improvement of the English version, all comments and suggestions are welcome and should be addressed to:

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国家能源局

Announcement of National Energy Administrationof the People's Republic of China

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Approbation of 384 energy sector standards(Attachment 1) such as*TechnologicalRegulations for Electrical Prospecting of Hydropower Projects*, English version of 48 energy sector standards(Attachment 2) such as*Technical Guide for Rock-Filled Concrete Dams*, 7 energy sector standards of revision notice NO.1 (Attachment 3) such as*Technical Code for Environmental Impact Assessment of Wind power Projects*, abolition of 5 energy sector standards/plans (Attachment 4) such as *Standards for survey and design fees of Wind power Projects*, are issued by National Energy Administration of the People's Republic of China.

Attachment: 1.Directory of Sector Standards

2. English Version of Directory of Sector Standards

3. Revision Notice of Sector Standards

4. Sector standards and Catalogue Planned to be abolished

National Energy Administration of the People's Republic of China

November 4, 2019

Attachment 1:

Directory of Sector Standards

Serial number	Standard No.	Title	Replaced standard No.	Adopted international standard No.	Approval date	Implementation date
...						
10	NB/T 10233-2019	Code for Hydrologic Design of Hydropower Projects	DL/T 5431-2009		2019-11-04	2020-05-01
...						

Foreword

According to the requirements of Document GNKJ[2015] No.283 issued by National Energy Administrationof the People's Republic of China, *Notice on Releasing the Development and Revision Plan of Energy Sector Standards in 2015*, and after extensive investigation and research, summarization of practical experience and wide solicitation of opinions, the drafting group has revised this code.

The main technical contents of this code include: basic data, meteorology, runoff, flood, sediment, evaporation, water temperature and ice regime, water stage, stage-discharge relation,and hydrologic telemetry and forecasting system.

The main technical contents of the revision in this code are as follows:

— Three chapters have been added, that is flood, sediment and hydrologic telemetry and forecasting system, with emphasis on making relevant provisions in terms of general provisions, main work content and requirements for design results.

— A section of "hydrologic investigation " has been added, which mainly includes water survey, storm investigation, flood investigation, low-flow runoff investigation,ice regime investigation and sediment investigation, etc.

— A section on "runoff characteristic analysis" has been added, and relevant provisions have been added on runoff and low-flow runoff analysis and calculation methods in areas where hydrologic data is short or absent.

— The relevant provisions on the analysis and calculation of multiple stage-discharge relations and the transfer of stage-discharge relation at the design section have been added.

— The appendix of evaporation difference method in runoff restoring calculation is added.

— Relevant provisions on the length of data series for theinterpolation and extrapolation of runoff series and runoff frequency calculation have been revised.

National Energy Administration of the People's Republic of China is in charge of the administration of this code. China Renewable Energy Engineering Institute has proposed this code and is responsible for its routine management. Energy Sector

Standardization Technical Committee on Hydropower Planning, Resettlement and Environmental Protection is responsible for the explanation of the specific technical contents. Comments and suggestions in the implementation of this code should be addressed to:

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Contents

1 General Provisions

1.0.1 Thiscodeisformulated with a view to specifying theprinciples, contents, methods and technical requirementsfor hydrologic design of hydropower projects.

1.0.2 Thiscode is applicable to the hydrologic design of hydropower projects.

1.0.3 The basic data shall be further collected, and multiple calculation methods shall be used for hydrologic analysis and calculation. Hydrologic design results shall be proposed according to the project design requirements.

1.0.4 The basic data shall be further investigated, fully processed and reviewed, and hydrologic characteristics and the influence of human activities on hydrologic elements shall be analyzed.

1.0.5 When the gauged hydrologic data of project area and adjacent river is insufficient, it's necessary to set up hydrometric stations or add measuring items in accordance with the design requirements.

1.0.6 The data series adopted in hydrologic designshall be reliable, consistent and representative.

1.0.7 The hydrologic calculation methods shall be scientific and practical, and the reasonableness of the calculation results shall be checked in different ways.

1.0.8 It is necessary to use multiple calculation methodsfor hydrologic calculation in the area wherehydrologic data is short or absent, or in low availability. Furthermore, the calculated results shall be comprehensively analyzed and reasonably chosen.

1.0.9 In addition to this code, the hydrologic design of hydropower projects shall also comply with the relevant current standards of China.

2 Terms

2.0.1hydrologic design

A general term of quantitative calculation of hydrometeorological elements such as precipitation,evaporation, discharge,river stage, sediment, etc. statistical analysis on hydrologic characteristics, research on the principles of formation and the patterns of spatial and temporal variation for hydrologic phenomena, plan and overall design for hydrologic telemetry and forecasting system, providing hydrologic result for engineering plan, design, construction and management.

2.0.2hydrologic investigation

Collecting hydrologic information and related information by means of reconnaissance, observation, investigation, identification and experimentation, etc.

2.0.3design basis station

Hydrometric station located at the project area orupstream and downstream of the project area which provides hydrologic data for the engineering hydrologic design.

2.0.4design benchmark station

Hydrometric stationfrom which hydrologic data are transferred for engineering hydrologic calculation or which is used as a control station for analysis and demonstration.

2.0.5 runoff analysis and calculation

The work of quantitative analysis and calculation of the multi-year variation of runoff and the distribution of runoff within a year.

2.0.6restoring calculation

In order to maintain the consistency of the data series, discharge and river stage data under the unnatural conditions shall be recovered to their natural conditions.

2.0.7runoff modulus

The runoff volume produced per unit of time per unit of catchment area.

2.0.8runoff coefficient

The ratio of the depth of runoff over the catchment area to the corresponding areal precipitation in any period of time.

2.0.9low-flow runoff

Minimum flow of the streamflow in low-flow period, runoff volume in the driest period and its temporal distribution.

2.0.10particle size distribution; grain size distribution.

The percentage of the ratio of the size of the sediment in a sample and the amount of sediment less than that size to the total sediment load.

3 Basic Data

3.1 BasicData Collection and Processing

3.1.1 Basicdata shall be collected and processed according to the design requirements, which mainly includes the following contents:

1Overview on the physical geography of the design basin, including geographical position, terrain, landform, geology, soil, vegetation andclimate, etc.

2 Characteristics of design basin and river channel, including the catchment area, elevation, slope, geometric features, noncontributing area in the design basin, length of the river, distribution of tributaries, morphological characteristics of the river channel in the project area, longitudinal and cross-sectional profile, etc.

3 Distribution and basic information of hydrometric stations, includingthehydrometric network distribution, the evolution of design basis station and design benchmark station,catchment area, elevation system, station control, observation items, observation methods and interval, processing information, etc.

4Hydrologic data, includingriver stage, discharge, river gradient, roughness, longitudinal and cross-sectional profile, sediment,precipitation, evaporation,water temperature, and ice regime, data of flood and low-flow investigation, restoring calculation data of runoff, flood and sediment.

5 Overview on the hydropower and water resources projects as well as the soil and water conservation measures,including water storage project, water diversion project, water pumping project, plan, design and operation data of embankment project, flood storage project, flood retarding project, flooddiversion project, and kinds of soil and water conservation measures.

6 Meteorological data,including the basic information of meteorological stations in the design basin and adjacent regions, station elevation, measured data of hydrologic stations and meteorological stations such asprecipitation,evaporation,air temperature, atmospheric pressure, humidity, wind speed,wind direction, sunshine duration,ground temperature,thunderandlightning, fog,frost period, ice period, snow

depth, depth of frozen soil, number of freeze-thaw cycles, sounding data, etc.

7Special data required for hydrologic analysis and calculation in the area recharged by ice and snowmelt runoffand karst area.

8 Dam-break flood data of barrier lake, including time of barrier and outburst, location, rupture shape, size, elevation and stage-capacity curve of barrier lake, river stage in the course of the dam-break flood,discharge hydrograph, etc.

9 Analysisand researchresult, including hydrologic and meteorological analysis result of the design basin and adjacent regions.

3.1.2 Hydrologic processed data of station since its establishment shall be collected. Data with anomalies which occurred in recent years that have not yet been processed, shall be supplementary collected according to the design requirements, and hydrologic elements shall be investigated and analyzed.

3.1.3 The data source, station's basic situation, measuring method andaccuracy of the collected data shall be ascertained, and the data shall be sorted out.

3.2 Hydrologic Investigation

3.2.1 Hydrologic investigation shall be conducted according to the project design requirements, such as water survey, storm investigation, flood investigation, low-flow investigation,ice regime investigation and sediment investigation, etc.

3.2.2 Water survey shall mainly include significant changes of catchment boundary and the catchment area, runoff volume and itemized water which affect runoff volume, water storage, water taking, water recession, water consumption, flood diversion, outburst, exchange water between basins, and reliability evaluation of water survey result.

3.2.3 Storm investigation shall mainly include the maximum storm or magnitudein various locations and duration, storm starting and ending time, storm intensity and temporal distribution, spatialdistribution and direction of stormcenter, coverage of the storm greater than a certain magnitude, weather condition before the rain and at that time, storm causes, storm disasters, analysis of storm return period and reliability of the investigated storm.

3.2.4 Flood investigation shall mainly include the flood occurrence time, flood marks, flood causes, flood sources, flood duration and fluctuation, riverbed composition, channel scour and deposition and its fluvial process, calculation of the flood peak discharge, flood volume and flood process, flood disasters, documents and historical relics concerned withthe flood records, analysis and verification of flood return period, and reasonableness analysis of the flood investigation result.

3.2.5 Low-flow investigation shall mainly include the starting and ending time of low-flow period, changes of river stage and discharge during this period, low-flow causes and sources, the spatial distribution,duration and disasters of low-flow, zero flow or not in the river, the causes, occurrence time and duration of zero flow, influence of human activities on low-flowrunoff, calculation of low-flow discharge, analysis and verification of low-flow return period, and reasonableness analysis of the low-flow investigation result.

3.2.6 Ice regime investigation shall mainly include initial ice, border ice, slush ice run, drift ice, water flow over ice, melting ice, ice jam, ice dam, date of first ice, freeze-up, break-up, and end-ice in ice-formation period, thethicknessof the largest ice and the volume of ice.

3.2.7 Sediment investigation shall mainly include the sediment sources, distribution of sediment contributing areas, changes of sediment load in a year, channel scour and deposition and its fluvial process, overview of human activities, water and soil losses, landslide, debris flow and other geological hazards, effects of projects already built or under construction on the river sediment.

3.3 Basic Data Review and Evaluation

3.3.1 Data shall be checked when being used for hydrologic design, such as characteristics of the design basin and river channel, hydrologic data and runoff restoring data. Data which obviously affects the calculation result shall be especially reviewed. Data with obvious error or systematic deviation shall be corrected and archived for future reference. Furthermore, reliability of the adopted data shall be evaluated.

3.3.2 Basin characteristic data shall be especiallyreviewedon catchmentarea of the designsection,design basis station and design benchmark station using the updatedtopographic mapwithproper scale.

3.3.3 Review of river stage data shall cover the changes of staff gauge's position, elevation systems, staff gauge zeros, and scour and deposition on cross-section as well as analyzing their influence on the river stage. Stage data which has poor observation accuracy, big changes of scour and deposition on cross-section, or significantly affected by human activities, especially the extremevalues,shall be especially reviewed. The reviewing methods shall include continuity analysis with its stage hydrograph; comparison analysis with the stage hydrographs of the upstream and downstreamstations or the stationsinadjacent basins; and correlation analysis with hydrologic elements.

3.3.4 Discharge data with low measurementaccuracy shall be especiallyreviewed by comparing the annual stage-discharge relations over years, dischargeandstage hydrographs, analyzing the water balance between upstream and downstream stations, as well as examining whether float coefficient and water surface velocity coefficient are reasonable or not, borrowed cross-section is reasonable or not, ice flow correction method and correction coefficient are reasonable or not, etc.

3.3.5 Review of reservoir runoff restoring data shall focus on reservoir stage, stage-capacity curve, accuracy of water release structure's discharge flow curve, reservoir seepage volume, the increased evaporation in reservoir area, etc. Runoff restoring data of other hydropower and water resources projects as well as soil and water conservation projects shall be reviewed according to its analysis and calculation basis and method, as well as the water balance calculation.

3.3.6 Review of meteorological data shall focus on the analysis and inspection of anomalies from the aspects of site location, instrument types, observing and processing methods, etc.

4Meteorology

4.1 General Requirements

4.1.1 Statistical analysis on meteorology shall ascertain the distribution and observation conditions of meteorological stations of the design basin and adjacent regions. Design representative station shall be adopted from adjacent stations wherethe physical and geographical conditions are similar to the project area.

4.1.2 Dataseries applied to meteorological statistical analysis should not be less than 30 years, otherwise data series should be interpolated and extrapolated.

4.1.3 If meteorological data is short or absent, or notrepresentative, thus cannot meet the design requirements, meteorological station shall be set up.

4.2 Climatic Characteristics Analysis

4.2.1 Analysis of climate characteristics shall include climatic characteristicsof the design basin as well as the project area.

4.2.2 Climatic characteristics of the design basin as well as the project area shall be summarized on the basis of its meteorological statistics and analysis results and combined with the physical and geographical conditions of the basin.

4.3 Meteorological Elements Calculation in theProject Area

4.3.1 Calculation of meteorological elementsin the project areashall becarried out according to the design requirements, which mainly include as follows:

1 Average annual and monthly air temperature, extreme values of annual and monthly air temperature as well as its occurrencetime, number of days of average monthly, average daily and minimum daily air temperature at different magnitudes, number of air temperature sudden drops and freeze-thaw cycles, etc.

2 Average annual and monthly precipitation, annual maximum precipitation in the specified duration as well as their occurrencetime, days of precipitation at different magnitudes.

3 Average annual and monthly wind speed, maximum annual and monthly wind

speed as well as their occurrence time and corresponding directions, number of days of wind speed at different magnitudes.

4 Average annual and monthly evaporation.

5 Average annual and monthly ground temperature and humidity, extreme values of annual and monthly ground temperature and humidity as well as its occurrencetime.

6 Appearing days of thunderstorm, frost, snow and fog as well as their occurrencetime.

7 Sunshine duration, snow depth, depth of frozen soil,etc.

4.3.2 When there is a long-termdata series of meteorological observation data in the project area, meteorological elements in the project area shall be statistically calculated directly.

4.3.3 When meteorologicalobservation data is short or absent, ornotrepresentative in the project area, meteorological elements in the project area shall be statistically calculated or modified by long-term data series of meteorological data, meteorological elements isoline map and the geographic variation of meteorological elements, where it is close to the project area andhas similar meteorologicalcharacteristics .

4.3.4 Reasonableness analysis and check shall be conducted on the characteristics of design meteorological elements.

5 Runoff

5.1 General requirements

5.1.1 The runoff analysis and calculation shall mainly include the following contents:

1 The runoff characteristics analysis;

2 The influence of human activities on the runoff and the restoring calculation of the runoff;

3 Runoff data interpolation and extrapolation;

4 Representativeness analysis of the runoff series;

5 Calculations of the design annual runoff and the design runoff over different periods, as well as their temporal distributions;

6 Check on the reasonableness of runoff calculation results.

5.1.2 The natural runoff series shall be used in the runoff analysis and calculation. In special cases, the runoff series under a consistent formation condition may also be used.

5.1.3 Runoff analysis and calculation shall be carried out according to the special characteristics of runoff in the region recharged by ice-snow melt runoff or in the karst area.

5.2 Runoff characteristics analysis

5.2.1 Runoff characteristics analysis shall mainly include runoff source, runoff spatial and temporal distribution, low-flow runoff and duration.

5.2.2 Runoff characteristics shall be analyzed according to basin runoff statistics and analysis results, and combined with the main factors affecting basin runoff.

5.3 Runoff Restoring Calculation

5.3.1 The runoff data obviously affected by human activities or under a significantly changing formation condition shall be restored.

5.3.2 The runoff needed restoring shall mainly include as follows:

1 The industrial, agricultural and domestic water consumption;

2 Volume variation of the water storage project and the increased evaporation in reservoir area;

3 Flood diversion volume and river diversion volume;

4 Interbasin water diversion volume;

5 Volume affected by soil and water conservation measures.

5.3.3 According to the data availability and the accuracy requirements of the calculation, runoff restoring calculation shall be performed with itemized investigation method, multivariate regression analysis method, rainfall-runoff relation method and evaporation difference method, which shall comply with the provisions in Appendix A of this code.

5.3.4 The runoff restoring calculation should be performed with years and months. When the required basic data is insufficient, the yearly restoring calculation should be performed with restored volumes of the typical wet, normal and dry years within each period which is divided according to the similarity of impacts of human activities on the runoff, and the monthly restoring calculation should be performed in the main water consumption period and the non-main waterconsumption period. When regional differences of the impacts from human activities are significant, runoff restoring calculation shall be performed in subregions.

5.3.5 Reasonableness of runoff restoring results shall be checked by examiningthe single index, the restored volume of each item, the balance of upstream and downstream volumes , the balance of volumes of main stream and tributaries, and the change of rainfall-runoff relation .

5.4 Runoff Data Interpolation and Extrapolation

5.4.1 The runoff series shall not be less than 40 years. When the gauged runoff series is less than 40 years or not representative, runoff series shall be interpolated and extrapolated. The interpolation and extrapolation range shall be determined based on the data availability,the interpolation accuracy and the requirements of the representativeness analysis.

5.4.2 According to the data availability, the interpolation and extrapolation of runoff series shall meet the following requirements:

1 When the stage-discharge relation is stable, runoff series shall be interpolated and extrapolated with the stage data. If the freeze has an obvious impact on the stage-discharge relation, runoff series within the freezing period shall be interpolated and extrapolated with the correcting coefficient method.

2 When there is a good correlation between runoff elements of design station and those of the upstream and downstream stations or the stations located in the adjacent similar basins, runoff series shall be interpolated and extrapolated with runoff elements of the stations which have longer data series.

3 When the rainfall-runoff relation is good in the design basin or the basin with similar physical and geographical characteristics, runoff series shall be interpolated and extrapolated with the longer rainfall series.

5.4.3 When interpolation and extrapolation of runoff series are performed, there shall be a clear causal relationship between the correlative runoff elements. When the correlative points are scattered or some correlative points deviate from the group obviously, the resulting reasons shall be analyzed carefully, and the correlation shall be improved by adding parameters according to the generation causes. The extrapolation range of runoff series interpolated with the correlation method should beless than 50% of the range of gauged runoff series.

5.4.4 Reasonableness of interpolated and extrapolated parts of runoff series shall be checked on the runoff coefficient, runoff modulus and the water balance between the upstream and downstream.

5.5 Runoff Series Representativeness Analysis

5.5.1 Representativeness analysis of runoff series shall adopt all the data with reliability and consistency.

5.5.2 Representativeness of runoff series shall be evaluated by analyzing the change patterns of statistical parameters of runoff series and the composition of runoff series in wet, normal and dry year or year group.

5.5.3 According to the data availability, the representativeness analysis of runoff series shall meet the following requirements:

1 When runoff series of the design basis station is long, representativeness of runoff series shall be analyzed with the cumulative average curve,residualmass curve and the moving average curve .etc.

2 When runoff series of the design basis station is short, and runoff series of the benchmark station is long in the upstream or downstream or the adjacent basin with similar physical and geographical characteristics, the representativeness shall be analyzed with the corresponding short series of the benchmark station.

3 In the basin recharged mainly by precipitation, when runoff series of the design basis station is short and precipitation series is long in the design basin or the adjacent basin with similar physical and geographical characteristics, the representativeness should be analyzed and evaluated with the corresponding short precipitation series.

5.6 Runoff Analysis and Calculation

5.6.1 Runoff series for the frequency calculation shall not be less than 40 years. The statistical interval shall be a year or different periods according to the design requirements.

5.6.2 In a runoff series composed of *n*consecutive items, the empirical frequency $P_m$of the *m*th item sorted by descending order shall be calculated according to the following formula:

$$P_m = \frac{m}{n+1} \times 100\% \quad (5.6.2)$$

where

n isthe number of consecutive items in the runoff series;

m is the order number of the item in the runoff series, m=1,2,…,n;

P_m is the empirical frequency for the mth item.

5.6.3 For the gauged or investigated special dry samples, return periods of them shall be determined after verification, then the empirical frequency of them shall be calculated with the mathematical expectation formula.

5.6.4 Pearson type III distribution curve shall be adopted in runoff frequency calculation, and the other curves may also be available afteranalysis.

5.6.5 The statistical parameters of Pearson type III distribution curve shall be expressed as the mean value $\overline{X}$, the coefficient of variation $Cv$and the coefficient of skewnessCs, which may be preliminarily estimated with the moment method and finally determined with the empirical curve fitting method. When the trend of runoff series is fitted, the normal and dry years shall be highlighted.

5.6.6 Runoff of the design section shall be calculated according to the runoff results of the designbasis station, and the results shall be modified considering the differences of catchment area, precipitation and underlying surface conditions.

5.6.7 The design runoff shall be performed by the long series or the series in the representative years according to the design requirements and the data availability. The calculation interval shall be a month、tendays or oneday according to the project storage capacity.

5.6.8 Runoff volumes in the representative years shall be equal to the design values, and their distribution processes shall be derived from the runoff processes in the typical years by the volume ratios. The typical years should include the wet year, normal year and the dry year, and they should be selected from the runoff series with high measurement accuracy. Besides, the annual water volumes of the typical years shall be close to the design values.

5.6.9 When the runoff series is short or absent, or notrepresentative,multiple methods shall be used to calculate runoff. The runoff result shall bereasonably selected after a comprehensive analysis. Depending on the data availability, multiple calculation methods shall be used to calculate the design runoff, such as hydrologic analogy method, the isoline map, runoff coefficient method, empirical formula method, basin-scale hydrologic model method, and the regional synthesis method. Each calculation method shall meet the following requirements:

1When the hydrologic analogy method is used, the hydrometric station located in adjacent basin with similar runoff characteristics and long measured data series shall be selected as the design benchmark station. When the design result is transferred, it shall be modified considering the differences of factors impacting the runoff.

2 When the isolinemap is used, the latest hydrologic atlas approved by the competent authority at or above the provincial level shall be selected and their

applicability and conditions shall be clarified. When the design basin is non-enclosed, runoff results should be modified according to the non-partitioned factors such as soil properties, scouring depth of river channel, buried depth, and flow characteristicsof groundwater.

3 When the runoff coefficient method is used, the runoff coefficient may be looked up inisolinemap or mayadopt the runoff coefficient in adjacent similar basin for reference. Then the runoff results may be calculated according to representative precipitation series of the design basin.

4 When the empirical formula method is used, it is necessary to analyze whether empirical formula is applicable to the design basin. When the formula is applicable, the calculation parameters shall bereasonably determined by the investigation, measurement, and isolinemap.

5 When the basin-scale hydrologic model is used, the model parameters shall be calibrated with the measured data. And the runoff results shall be calculated according to representative precipitation series of the design basin.

6 When the regional synthesis method is used, comprehensive relationship between runoff statistical parameters or design values and catchment area shall be analyzed according to the discharge data of each hydrometric station in the project area and adjacent regions. Then the runoff shall be calculated according to catchment area at the project design section.

5.6.10 Runoff series may be generated with the stochastic simulation method according to the engineering design requirements.

5.6.11 Runoffresults shall be subject to reasonableness check by analyzing the water balance between upstream and downstream reaches, the balance between main stream and tributaries, the change pattern of runoff statistical parameters in adjacent regions, and the rainfall-runoffcorrespondence in spatial and temporal distribution, etc.

5.7 Low-flow Runoff Analysis and Calculation

5.7.1 Low-flow runoff analysis and calculation shall include the minimum discharge, the minimum daily discharge, the runoff in the driest period and its temporal distribution.

5.7.2 The restoring calculation of low-flow runoff should use methods of itemized investigation, regression curve, the relationship of low-flow runoff between short series and long series or between upstream and downstream, etc. The interpolation and extrapolation of low-flow runoff series should use methods such as stage-discharge relation, discharge relation between design basis station and benchmark station in upstream and downstream reaches or in adjacent similar basins, the recession curve, etc.

5.7.3 The return period of the extraordinary low runoff shall be determined with the comprehensive analysis based on the historical documents and relics, the investigated data, as well as the long precipitation and runoff series in the design basin and the adjacent similar basin.

5.7.4 Generally，low-flow runoff analysis and calculation shallcomply with the provisions mentioned in 5.6.1~5.6.11. When there are zero values in the series，the frequency calculation may be proceeded considering zero values.

5.7.5 When the low-flow runoff data series is short or absent, methods such as the hydrologic analogy method, low-flow runoff zoning method and empirical formula method should be used to calculate the low-flow runoff at the project design section. According to the project design requirements, low-flow investigation shall be carried out in design reach to modify the calculated results.

5.7.6 Low-flow runoff results shall be subject to reasonableness check by analyzing the change pattern of low-flow statistical parameters in upstream and downstream reaches, main stream and tributaries, and the adjacent regions, as well as analyzing the underlying surface characteristics, rainfall and drought during dry period, and the impact of human activities in the design basin, etc.

5.8 Snowmelt Recharge Area Runoff Analysis and Calculation

5.8.1 When the glacier coverage ratio in the design basin exceeds 5%, or the runoff is significantly influenced by ice-snow melt, the stage and discharge in summer shows obvious daily variation, the runoff analysis and calculation shall take ice-snow melt characteristics into consideration.

5.8.2 The basic data collected in the region recharged by ice-snow melt runoff shall also include area and storage of the glacier corresponding to the elevation change, volume of the glacial lake, the glacial lake burst and its influence along the way, the ground and air meteorological observations of the glacier stations and the adjacent regions, as well as the existing analysis results, etc.

5.8.3 The impacts from artificial ice-snow melt and the glacier lake burst should be considered in the runoff restoring calculation in the region recharged by ice-snow melt runoff.

5.8.4 Interpolation and extrapolation of runoff series in the region recharged by ice-snow melt runoff should take air temperature into account when analyzing the similarity of the local catchment or the adjacent basins and building the correlations.

5.8.5 Representativeness analysis of runoff series in the region where the ice-snow melt runoff has a relatively great recharge proportion shall be comprehensively analyzed by combining the runoff or precipitation data with the change of air temperature.

5.8.6 The ice-snow melt runoff analysis and calculation shall comply with the provisions in 5.6.1~5.6.11.

5.8.7 The calculation results reasonableness of the ice-snow melt runoff shall be comprehensively analyzed by checking the ice-snow ablation patterns, the proportion of ice-snow melt runoff in the total runoff and the afflux location, etc.

5.9 Karst Area Runoff Analysis and Calculation

5.9.1 When the annual runoff coefficients of the design basis station and the station in the adjacent non-karst area differ over 20%, and the runoff processes of themwithin a year are obviously different, and the drainage areas of the design basis station, which are encircled by the surface and groundwater divide respectively, differ over 20%, runoff analysis and calculation shall be carried out on the basis of the runoff characteristics in the karst area.

5.9.2 The basic data collected in the karst area shall include the groundwater divide of the design basis station and the design basin, funnel, karst cave, underground stream and other hydrogeological data.

5.9.3 Runoff restoring calculation in karst area shall comply with the provisions in 5.3.1~5.3.5 of this code. Runoff restoring calculation affected by underground reservoirs shall also take the influence of underground reservoirs into account.

5.9.4 When the runoff data is interpolated and extrapolated with the upstream and downstream stations or converted with the area ratio, the impacts of karst difference of the local catchment on runoff shall be considered.

5.9.5 When runoff process within a year of the design section is calculated with the data of benchmark stations in upstream and downstream or the adjacent rivers, the result shall be modified considering the difference of karst influence in the local catchment or the two areas.

5.9.6 When checking the runoff reasonableness in karst area, all the items related to the drainage area shall adopt the restored results corresponding to the enclosed basin which eliminate the influence of non-enclosed basin.

6 Flood

6.1 General Requirements

6.1.1 Design flood analysis and calculation shall include:

1Stormflood characteristics analysis.

2 Flood Series consistency processing and interpolation and extrapolation.

3 Investigation and verification of historical flood and storm data.

4 Calculation of design flood based on flow data.

5 Calculation of design flood based on stormdata.

6 Calculation of design flood affected by upstream reservoir regulation.

7 Calculation of seasonal design flood and construction design flood.

8 Reasonablenesscheck on the design flood calculation results.

6.1.2 When extreme storm and flood occur in the design basin, the results of the design storm and the design flood shall be analyzed and reviewed.

6.1.3 Flood calculation in areas such as arid, karst, glacier, or tidal reach shall be carried out according to their special physical and geographical conditions and hydrologic characteristics.

6.1.4 When the conditions of runoff yield and flow concentration are obviously changed by human activities in the design basin, the influence of human activities on them shall be analyzed and determined in flood calculation.

6.1.5 The calculation of ProbableMaximum Precipitation and ProbableMaximum Flood shall be carried out according to the needs of projects, and shall comply with therelevant current standard *Code forProbableMaximumFloodCalculation of Hydropower Projects* NB/T 10234.

6.1.6 The flood calculation shall comply with the relevant current standard*Code forCalculatingdesign flood of Hydropower Projects*NB/T 35046.

6.2 Flood analysis and calculation

6.2.1 The main contents of storm and flood characteristics analysis include storm cause, storm magnitude, storm starting and ending time, storm regional change pattern, flood cause, flood seasonal change pattern, flood frequency and interannual change range, flood duration and fluctuation characteristics.

6.2.2 The flood series used in the design flood calculation shall be subject to consistency analysis and treatment. When the measured flood and storm series are short or there are missing data in the measured period, the flood and storm data shall be interpolated and extrapolated.

6.2.3 During the design flood calculation, the reasonableness of historical flood and storm data and their compilation results shall be checked. According to the data availability and project design requirements, the historical flood and storm data shall be supplemented and verified.

6.2.4 The calculation of design floods based on flow data series shall meet the following requirements:

1The flow data series used for design flood calculations shall not be less than 40 years.

2 Frequency analysis method shall be adopted for design flood calculation. According to the project design requirement, the design flood hydrograph shall be calculated using the typical flood hydrograph according to the same frequency enlargement method or the same multiplier enlargement method.

3 The design flood of the project design section shall be calculated according to the flood results of the design basis station, and the results shall be modified considering the differences of catchment area, storm and underlying surface condition.

4 According to the data availability and project design requirements, the inflow design flood shall be calculated by frequency analysis method, typical inflow flood amplification method, and flow inversion method. For constructed reservoirs with obvious changes in runoff yield and flow concentration conditions, when the flood regulation results are significantly different in using the dam site design flood and the inflow design flood, the inflow design flood should be adopted as the design basis.

6.2.5 When flood data is short or absent, design flood shall be calculated from design storm during which runoff yield and flow concentration shall be calculated based on storm data, or design flood shall be calculated using regional comprehensive analysis according to hydrologic data of adjacent areas.

6.2.6 Calculation of design flood based on storm data shall meet the following requirements:

1 The design storm calculation shall include the calculation of point rainfall and area rainfall of different durations, storm temporal and spatial distribution, etc.

2 When the storm data series is not less than 40 years, the frequency analysis method shall be used to calculate the design storm with different durations. If extraordinary storm exists in the data series, its return period shall be determined according to the storm rainfall, flood and its impacts, and storm records in adjacent regions. When the storm rainfall data series is short or absent, isoline maps should be used to calculate the design storm with different durations and considering the storm point-area relationship.

3 When the design flood is derived from the design storm, the proper calculation method of runoff yield and flow concentration shall be adopted based on the hydrologic characteristics, basin characteristics and data availability of the design basin.

4 When the design basin is relatively large, the storm spatial distributing is uneven, and the conditions of runoff yield and flow concentration are apparently different , the calculation of runoff yield and flow concentration shall be divided into different units, and then the design flood is calculated after river flood routingand the combination of the base flow.

6.2.7 For large scale or important medium scale projects, comprehensive analysis and inspection shall be carried out for data availability, parameter selection, sampling error, etc. for flood calculation; if the check flood is likely to underestimate, the safety margin shall be determined through comprehensive analysis.

6.2.8 Where there is reservoir with greater storage capacity upstream of the project design section, the design flood impacted by the upstream reservoir regulation shall be calculated.

6.2.9 Where there is a dam-break flood of barrier lake in the upstream of the design section or there is a potential dam-break flood, the design flood affected by the upstream barrier lake dam-break shall be analyzed and calculated.

6.2.10 The reasonableness of design flood calculation results shall be checked. Multiple methods shall be used for the design flood calculation in the region where data is short or absent. The design flood results shall be reasonably selected after comparison.

6.3 Analysis and Calculation of Seasonal Design Flood and Construction Period Design Flood

6.3.1 The seasonal design flood calculation shall be carried out according to theproject design requirements, and shall meet the following:

1 When there are significant differences in the causes and magnitude of flood in different periods of flood season, the design flood in flood season shall be analyzed and calculated according to the design and reservoir operation requirements.The design flood in the main flood season shall be calculated according to the annual maximum flood calculation results, and the design flood in other flood season periods shall be calculated according to the flood series selected from each period respectively using the frequency analysis method.

2 Design flood in non-flood season shall be calculated by usingthe frequency analysis method with the flood series sampled from each period according to the maximum value method.

3 Where there is a storage reservoir upstream, the seasonal design flood of the project design section influenced by the upstream reservoir regulation shall be calculated.

6.3.2 The construction design flood calculation shall be carried out according to the project design requirements, and shall meet the following:

1 The period of constructiondesign flood shall be reasonably divided according to the seasonal change pattern of flood, the characteristics of the cause and the construction design requirements.

2 The samples of construction floods shall be selected according to the maximum

value method in each period. When selecting samples across periods, the results of construction design flood shall not be used across periods; when selecting samples are not across periods, the results of construction design flood may be used across periods.

3When the flood data series is sufficient, the frequency analysis method shall be used to calculate the construction design flood; when the flood data series is short or absent, the construction design flood may be calculated by hydrologic analogy method, and be modified based on the characteristics of runoff yield and flow concentration of the design basin.

4Where there is a storage reservoir upstream, the construction design flood of the project design section impacted by the upstream reservoir regulation shall be calculated.

7 Sediment

7.0.1 Sediment analysis and calculation shall include watershed sediment yield analysis, suspended sediment analysis and calculation, bed load analysis and calculation, and design water and sediment series selection.

7.0.2 Watershed sediment yield analysis shall mainly include sediment yield regional distribution, characteristics, causes and development trend of project-located watershed.

7.0.3 Suspended sediment analysis and calculation shall mainly include yearly and multi-year average suspended sediment load and suspended sediment concentration, inter-annual variation and intra-annual distribution of suspended sediment load and suspended sediment concentration, inter-annual and intra-annual variation of suspended sediment particle size distribution, correlation between flood peak and sediment peak, relationship between discharge and suspended sediment concentration.

7.0.4 The design basis station for suspended sediment calculation should have no less than 20 years of continuous sediment measurement data series. In case of the series less than 20 years, the sediment data series shall be interpolated and/or extrapolated. In case of the measured data in the series significantly affected by natural disasters or human activities, the sediment measured data shall be modified.

7.0.5 When the measured suspended sediment data isshort or absent in the project-located river, existing measured data, the sediment transport modulus diagram, measured data of adjacent similar river basins, empirical formula of suspended sediment load in the project-located area, suspended sediment sampling in flood period and other methods shall be used to estimate the suspended sediment load and particle size distribution.

7.0.6 Bed load analysis and calculation shall mainly include relationship between water discharge and bed load transport rate, relationship between water discharge and the characteristic particle size of bed load, and distribution characteristics of bed load within a year.

7.0.7 Bed load may be estimated by the following methods: using measured bed load data from the design basis station, deriving from bed load transport tests, using bed load transport rate formula, and using the ratio of bed load to suspended load.

7.0.8 The calculation results of suspended sediment and bed load shall be subject to reasonableness check.

7.0.9 The design water and sediment series should use the combination of representative series or the combination of representative years. The influence of human activities up to the design target year shall be considered for the design water and sediment series.

7.0.10 Sediment calculation shall meet the relevant requirements of current professional standard NB/T 35049, *Code for Sediment Design of Hydropower Projects*.

8 Evaporation, Water temperature and Ice Regime

8.1 Evaporation Analysis and Calculation

8.1.1 Evaporation analysis and calculation shall be carried out according to the project design requirements. The main calculation contents shall include average annual and monthly water surface evaporation, annual and monthly series of evaporation, the increased evaporation in reservoir area, and the reasonableness check of evaporation calculation results.

8.1.2 Thephysical and geographical conditions of evaporation station selected for water surface evaporation calculation shall be close to that of the design area.

8.1.3 The data series used in the calculation of water surface evaporation should not be less than 30 years.

8.1.4 According to the evaporation data availability and the type of observation instrument, the calculation method of water surface evaporation shall meet the following requirements:

1 The evaporation of evaporation tank with a surface of no less than $20m^2$ shall be taken as those of the local large water body. When the physical and geographical conditions of the design area are similar to those of the observation site, the evaporation of the design area shall be directly transferred from those of the observation site, and when the evaporation difference is obvious, the evaporation of the design area shall be modifiedin case of the influencing factors.

2 The observation data of E-601, 20cm and 80cm evaporation pans shall be converted into the evaporation capacity of $20m^2$ evaporation tank, and then converted to the design area. The water surface evaporation convert coefficient of E-601 evaporator shall meet the requirements of Appendix B of this code.

3 The observation data of floating evaporator may be used to calculate the water surface evaporation in the design area after eliminating the influence of improper floating raft structure, installation and observation method.

8.1.5 When water surface evaporation data is short or absent, the water surface evaporation may be calculated using the latest isoline map or regional empirical formula method approved by the provincial and higher administrative authorities. According to the project design requirements, water surface evaporation data shall be observed by additional new stations or observation items.

8.1.6 The evaporation of water surface and land surface used in the calculation of the increased evaporation in reservoir area should be determined based on the analysis of data in areas with similar hydrologic and meteorological conditions near the reservoir.

8.1.7 The reasonableness of the evaporation calculation results shall be checked by comparing the results of similar projects nearby.

8.2 Water Temperature Analysis and Calculation

8.2.1 Water temperature analysis and calculation shall be carried out according to the project design requirements, and the main content shall include the water temperature statistics of design basis station, the water temperature calculation of design river section and the reasonableness check of water temperature results.

8.2.2 The characteristic values of water temperature for statistical analysis shall include the average value of annual and monthly water temperature, the highest and lowest value of annual and monthly average water temperature, the annual highest and lowest value of water temperature as well as their occurrence time .

8.2.3 The data series used for water temperature statistics shall not be less than 30 years. Otherwise, it shall be interpolated and extrapolated. Anomalies shall be reviewed.

8.2.4 The water temperature of the design reach shall be calculated using the statistical results of the water temperature at the design basis station, and the differences of the factors affecting the water temperature shall be analyzed. When the difference of influencing factors of water temperature is obvious, the calculation results of water temperature shall be modified.

8.2.5 When the water temperature data is short or absent, special stations or observation items shall be added.

8.2.6 The calculation results reasonableness of water temperature shall be checked by comparing adjacent similar reach and considering meteorological conditions such as temperature and solar radiation.

8.3 IceRegime Analysis and Calculation

8.3.1 For the design river reach with ice regime, the characteristic value of ice regime shall be calculated, the characteristics of ice regime shall be analyzed, and the ice regime during the construction and operation period of the project shall be analyzed.

8.3.2 The ice regime characteristic values of river for statistical analysis shall mainly include the following:

1 The average, earliest and latest date of initialice,slushice run, freeze-upbreak-up, drift ice and endice.

2 Concentration of slush ice run, total amount of slushice run and maximum frazilslushflow before freeze-up.

3Evolution of ice thickness, maximum ice thickness and time of occurrence, maximum thickness of frazilslush and time of occurrence during the freeze-upperiod.

4 Concentration, total volume, maximum ice block size, speed of drift ice and maximum ice flow during break-up period.

5 The probability of different types of break-up.

6The occurrence time, location, scale and evolution of icejam and ice dam.

8.3.3 When there are ice regime observation data that have basically the same influence on human activities over 10 years, the ice regime characteristic values shall be calculated directly. When the data seriesis less than 10 years, the ice regime characteristic value shall be determined according to the comprehensive analysis of the ice investigation.

8.3.4 When the hydraulic and thermodynamic conditions of the design section and the design basis station are similar, the statistical characteristic value of ice regime of design section shall be directly transferred from the design basis station. Otherwise, the ice regime characteristic values at the design section shall be modified by comparative observation and investigation data analysis.

8.3.5 When ice regime observation data is short or absent, the ice regime characteristic value shall be estimated by the ice regime characteristic chart, the regional empirical formula method, and the heat balance method.

8.3.6 The ice regime analysis and calculation of the project shall mainly include the following contents:

1 Process of design flow and ice.

2 Diversion, ice release capacity of facilityand design backwater height of the design reach.

3 The ice thickness of the reservoir and the possibility of ice jam and ice dams at the end of the reservoir and the possible backwater height.

4 Changes in ice regime along the channel and its impact on water transportation capacity.

5 The icing characteristics of the upper and lower reservoirs of the pumped storage power station, the maximum ice storage capacity and the anti-icing requirements for the operation mode of the hydropower station.

6 The zero-temperature section at the downstream of the reservoir and the unfrozen distance.

8.3.7 Before analyzing and calculating the ice regime of the project, the requirements for the construction and operation of the design project, the ice regime characteristics of the design river section and the ice regime changes before and after the construction of the existing project shallbe fully understood and analyzed.

8.3.8 Project ice regime shall be analyzed and calculated with the hydraulic, thermodynamic and hydrologic principles and methods. The analogy analysis may be adopted when the data is short or absent.

8.3.9 The ice analysis and calculation results of the projects shall be checked for reasonableness. According to the project design requirements, the ice regime calculation results of theproject may be determined based on model tests.

9 Water Stage

9.1 RiverStageAnalysis and Calculation

9.1.1 According to the data availability,the design river stage shall meet the following requirements:

1The design stage shall be calculated by using the design discharge whenthe design discharge and stage-discharge relation is available.

2The design stageshall be calculated by using the stage frequency calculation when only the stage data is available.

9.1.2 The stage data used in frequency calculation shall be checked, andthe data series shall be over 40 years. Furthermore, the river channel shall be stable and the extents of human activities influence shall be consistent in the observation period.

9.1.3 When the stage data series is less than 40 years, it shall be extrapolated with correlation method or water surface profile method. Besides,the correlative factors shall have genetic relations with the stage.

9.1.4 Pearson type III distribution curve shall be adopted in stage frequency calculation, and the other curves may also be available afteranalysis.

9.1.5 The data series, which subtracts the constant stage from the gauged stage, should be used in stage frequency calculation.Then the design stage should be calculated by the result plus the subtracted value.

9.1.6 The design stage of the design section shall be converted from that of the station with the stage correlation method, water surface profilemethod, etc.

9.1.7 Reasonablenesscheckon the design stage shall be focused on the extrapolation part of the stage frequency curve, which may be considered form the river characteristics and the correspondence between upstream and downstream station results, etc.

9.2 TidalStage Analysis and Calculation

9.2.1 The analysis and calculation contents of tidal stage shall mainly include the design high tidal stage, design low tidal stage, design tidal range, design tidal flow, design tidal stage hydrograph and the combination of design flood and design tidal elements in tidal reach.

9.2.2 Tidalstage calculation shall use frequency analysis method when the data series is over 30 years and meets the consistency requirement.

9.2.3 When the design standards of the tidal stage are high,historical tidal stage shall be investigated and used in the calculation, combined with the measured data series.

9.2.4 The Pearson type III distribution curve of tide stage should be adopted.

9.2.5 Whenthe tidalstage series of the design basis station is less than 30 years but more than 5 years, the adjacent station which has the synchronous series more than 30 yearsshall be selected and used as benchmark station to calculate the design tidal stage with the extreme synchronization difference ratio method. Besides, the tide characteristics and the influencing effects from the river runoff of the benchmark station shall be similar to that of the design basis station.

9.2.6 The design tidal stage hydrographshall bederived from smoothing the typical hydrograph, andcontrolled by the design tidalstage.

9.2.7 When the tidal buildings stand steeply to the coast, the backwater height of the high tidal stage and the impact on the low tidal stage shall be analyzed to modify the design tidal stage results.

9.2.8 The design tidalstage results shall be analyzed in multiple ways to check the reasonableness.

10 Stage-Discharge Relation

10.0.1 The stage-discharge relation of natural river channel at the project design section shall be derived according to the design requirements.

10.0.2 The elevation system used in stage-discharge relation shall be consistent with that of the project.

10.0.3 Theon-the-spot hydrologic investigation, gauging of the water stage, discharge and water surface gradient, and survey of longitudinal profile and cross-section of river channel shall be carriedout in the analysis of the stage-discharge relation.

10.0.4 Whenmeasured stage and discharge at the design section are available, the stage-discharge relation shall be derived according tomeasured data directly.

10.0.5 When only the gauged stage is available and the discharge in the upstream or the downstream may be transferred, the stage-discharge relation shall be derived on the basis of the gauged stage and transferred discharge, also transferred from the upstream or downstream stage-discharge relation with the stage correlation method. And it shall be modified when the local discharge is not negligible.

10.0.6 When the stage and discharge data in the river channelof the design section is absent, water stage and discharge measurement and flood and low-flow investigation shall be carried out in the design river channel. And combined with the data of cross-section and longitudinal profile of the river channel, stage-discharge relationshall be derived with multiple methods.

10.0.7 Extension of the stage-discharge relation for high stages shall use the stage-area relation and stage-velocity relation curve, the hydraulic formula, and be derived on the basis of flood investigation result. Extension of the stage-discharge relation for low stages shall be controlled by the stage of zero flow and determined based on low-flow investigation result.

10.0.8 When stage-discharge relation curves is unstable, the reason shall be analyzed. Multiple stage-discharge relations analysis shall be considered with the following situations:

1 The stage-discharge relation is influenced by the flood fluctuation.

2 The stage-discharge relation is influenced by the fluctuant backwater.

3 The stage-discharge relation is influenced by the scour and deposition.

4 The stage-discharge relation is influenced by the transverse gradient or the diversion.

10.0.9 Themultiple stage-discharge relation curves shall be analyzed and determined by the following methods according to main hydraulic influence factors and river channel characteristics.

1 When the river channel is influenced by the flood fluctuation, the stable stage-discharge relation curves should be derived, alsothe enveloping curve or average curve of the flood fluctuation may be determined separately.Extension for high stages shall be based on the measured point with zero fluctuation rate, or analyzed after single curve which is determined by correction factor method.

2 When the river channel is influenced by the fluctuant backwater of downstream,a cluster of stage-discharge relation curves shall be analyzed and calculated with the parameter of the downstream river stage or discharge consideringthe influence of the backwater.If measured data is insufficient, the stage-discharge relation curves cluster may be derived by the hydraulic formula.

3 When the river channel is influenced by the scour and deposition, current stage-discharge relation curves shall be derived, moreover, stage-discharge relation curves of the design year shall be derived according to thedesign requirements.

4 When the river channel is influenced by the transverse gradient or the diversion, stage-discharge relation curves of left bank, right bank and the anabranched channel shall be derived separately according to the influence of the transverse gradient or the diversion.

10.0.10 The stage-discharge relation of the designsections shall be derived according to the result of stage-discharge relation of hydrologic stations, the difference of cross-section of river channel, water surface gradient and discharge.

10.0.11 Reasonableness of stage-discharge relation shall be checked on its curve variation trend, stage-velocity relation and stage-roughness relation according to the control condition of river reach and cross-sectioncharacteristic of river channel.

11 Hydrologic Telemetry and Forecasting System

11.1 General Requirements

11.1.1 The necessity of building a hydrological telemetry and forecasting system shall be analyzed and demonstrated, and if necessary, planning and overall design of the system shall be performed.

11.1.2 The design of hydrological telemetry and forecasting system shall comply with the currentrelevant standard*Technical specifications for hydrologictelemetry system of hydropower projects* NB/T 35003.

11.2 Planning Design

11.2.1 The necessity of the system shall be analyzed and demonstrated from such aspects as safety in flood season, power generation and multipurpose utilization of the project as well as eco-environmental protection of the basin according to the hydrologic characteristics of the basin, project characteristics and flood protection requirements.

11.2.2 The planning of the system shall cover the following:

1 Investigate and analyze the hydrometeorological characteristics, hydrologic station network, hydrologic telemetry system and transportation and communications conditions of the basin where the project is located, construction and operation characteristics of the project;

2 Propose the hydrologic forecasting configuration, telemetry coverage area and telemetry station network of the system;

3 Propose the mode, networking and work system for communications;

4 Propose the main equipment for telemetry stations, relay stations, central station and subcentral stations;

5 Propose the civil works required;

6 Work out the fundamental functions of the system;

7 Draw up the system construction plan and hydrologic service plan during the project construction period;

8 Roughly estimate the construction cost of the system and the hydrologic data measurement and forecasting service fee during the project construction period.

11.3 Overall Design

11.3.1 The overall design of the system shall include the following:

1 Collect and analyze the hydrometeorological characteristics, hydrologic station network layout, hydrologic telemetry system and transportation and communications conditions of the basin where the project is located, the construction and operation characteristics of the project;

2 Identify the fundamental functions of the system;

3 Determine the telemetry coverage area and telemetry station network of the system;

4Determine the mode, networking scheme and work system for communications;

5Determine the power supply mode, overvoltage protection and lightning protection earthing measures for the system;

6 Determine main equipment for the telemetrystation, relay station,center station and sub-center station of the system;

7 Propose the civil works for the system and their scales;

8 Propose the hydrologic forecasting scheme configuration;

9 Determine the data processor and software platform functions;

10 Work out the construction plan of the system and the hydrologic service plan during the project construction period;

11 Prepare the cost estimate for the system construction and for the hydrologic data measurement and forecasting service during the project construction period.

11.3.2 For a hydrological telemetry and forecasting system of cascade projects , the existing station network system shall be made full use of for reasonable connection, and the necessity of subcentral stations shall be demonstrated according to the construction, operation and management requirements of the projects.

Appendix ARunoffRestoring Calculation Methods

A.1 Itemized Investigation Method

A.1.1 Industrial, agricultural and domestic water consumption, volume change of the water storage project and the increased evaporation in reservoir area, interbasin water diversion volume, flood diversion volume and the other items shall be found out for itemized investigation method, and the influence degree of each water quantity item shall be analyzed.

A.1.2 The natural runoff shall be restored according to the following formula:

$$W = W_1 + W_2 + W_3 + W_4 + W_5 + W_6 \pm W_7 \pm W_8 \pm W_9 \pm W_{10} \pm W_{11} \quad \text{(A.1.2)}$$

where

W is natural runoff after restoring calculation (m^3);

W_1 is gauged and measured runoff (m^3);

W_2 is industrial net water consumption (m^3);

W_3 is agricultural net water consumption (m^3);

W_4 is domestic net water consumption (m^3);

W_5 is the increased evaporation in reservoir area (m^3);

W_6 is reservoir seepage volume (m^3);

W_7 is volume change of the water storage project. Its value is positive when the volume is increasing, otherwise its value is negative (m^3);

W_8 isinterbasin water diversion volume. Its value is positive when the water is diverted outof the design basin, otherwise its value is negative (m^3);

W_9 is flood diversion volume. Its value is positive while the water is diverted out of the design basin, otherwise its value is negative (m^3);

W_{10} is volume affected by soil and water conservation (m^3);

W_{11} is volume affected by other related factors, such as urbanization, exploitation and recharge of groundwater, ecotope changes, etc. (m^3).

A.2 Multivariate Regression Analysis

A.2.1 When the main itemscan notbe found out clearly in the investigation, and the data of the runoff and its main influencing factors is available, multivariate regression analysis shall be used to runoff restoring calculation.

A.2.2 A multiple regression equation shall be built on the basis of the natural runoff and its main influencing factors, which is extracted from the early data affected by human activities weakly. Then at the late stages the natural runoff which is affected by human activities obviously shall be calculated by inputting the relevant influencing factors to the equation.

A.3 Rainfall-Runoff Relation

A.3.1 Whenthe accuracy of rainfall-runoff relation is high,the restored water quantity shall be calculated by using rainfall-runoff relation, and rainfall-runoff correlation method or the hydrologic model method may be used.

A.3.2 With rainfall-runoff correlation method, the empirical relations among rainfall, runoff and the previous hydro-meteorological factorsshall be established to calculate the runoff and its temporal distribution corresponding to each rainfall, with the assist of reasonable unit hydrograph.

A.3.3 With hydrologic model method, a deterministic hydrologic modelshall be developed according to the relation between rainfall-runoff physical mechanism and its influencing factors, to calculate the runoff and its temporal distribution corresponding to each rainfall.

A.4Evaporation difference method

A.4.1 Evaporation difference method shall be used to calculate runoff restoring whentherunoff calculation period is relatively long and the gauged precipitation and evaporation data in the basin are representative.

A.4.2 Runoff restoring shall be calculated by the following formula when Evaporation difference method is used:

$$\Delta R = P - R - E_0 \tag{A.4.2-1}$$

$$E_0 = \frac{(A - A_{\mathrm{ws}})E_{\mathrm{ls}} + A_{\mathrm{ws}}\alpha E_{\mathrm{eva}}}{A} \tag{A.4.2-2}$$

where

ΔR is the change of runoff depth affected by human activities (mm);

P is Average areal precipitation of the basin (mm);

R is Runoff depth affected by human activities (mm);

E_0 is Evaporation of the basin before impact of human activities (mm);

A isThe whole catchment area of the design basin (km^2);

A_{ws} is The water surface area of reservoirs, lakes and ponds in the basin before impact of human activities (km^2);

E_{ls} isLand surface evaporation (mm);

α isConversion coefficient of water surface evaporation;

E_{eva} is Gauged water surface evaporation by evaporation pan (mm).

Appendix B Water Surface Evaporation Conversion Coefficient for E-601 Type Evaporation Pan

Table B Water Surface Evaporation Conversion Coefficient for E-601 Type Evaporation Pan

Climate area	Province (autonomous region, municipality directly under the Central Government)	Station name	Standard evaporation pool area m^2	Month												year	Statistical years
				1	2	3	4	5	6	7	8	9	10	11	12		
Moderate temperate zone	Jilin	Fengman	20	—	—	—	—	0.74	0.81	0.91	0.97	1.03	1.04	—	—	—	1965~1979
	Liaoning	Yingpan	20	—	—	—	—	0.80	0.82	0.88	0.96	1.02	0.97	—	—	—	1983~2015
	Heilongjiang	Erlongsan	20	—	—	—	—	0.78	0.81	0.91	0.92	0.99	0.97	—	—	—	1990~2017
	Inner Mongolia	Hongsan	20	—	—	—	—	0.73	0.76	0.77	0.85	0.88	0.85	—	—	—	1980~1982
		Bayan Goller	20	0.71	0.71	0.74	0.81	0.79	0.80	0.82	0.87	0.90	0.92	0.82	0.70	0.82	1984~2016
	Xinjiang	Hadipo	20	—	—	—	0.82	0.80	0.81	0.82	0.84	0.85	0.91	—	—	—	1964~1965
South Temperate Zone	Beijing	Guanting	20	—	—	—	0.82	0.81	0.86	0.95	1.02	1.01	0.97	—	—	—	1964~1970
	Sandong	Nansi Lake Level 2 Lake Gate	20	—	—	0.93	0.89	0.92	0.94	1.00	1.04	1.08	1.05	1.08	—	—	1985~1990
	Henan	Sanmenxia	20	—	—	—	0.84	0.84	0.88	0.87	0.97	1.02	0.96	1.06	—	—	1965~1967
Northern Subtropical	Hubei	Lushui Reservoir	20	0.85	0.82	0.76	0.79	0.85	0.87	0.91	0.97	1.00	0.99	0.96	0.92	0.90	1987~1999 2002~2013 2015~2016
		Yichang	20	0.97	0.87	0.83	0.80	0.88	0.90	0.91	0.99	1.01	1.02	1.05	1.03	0.93	1984~2016
		East Lake	10	0.98	0.97	0.88	0.92	0.93	0.95	0.98	0.99	1.04	1.05	1.06	1.04	0.98	1960~1961 1965~1977
	Jiangsu	Taihu	20	1.02	0.94	0.9	0.86	0.88	0.92	0.95	0.97	1.01	1.03	1.06	1.09	0.97	1957~1966
		Yixing	20	1.09	1.02	0.9	0.87	0.91	0.93	0.93	0.97	1.05	1.03	1.1	1.1	0.97	1961~1969
	Zhejiang	Dongxikou	20	0.92	0.85	0.78	0.83	0.87	0.89	0.91	0.94	0.97	0.96	0.94	0.93	0.9	1966~1973
Central Subtropical	Chongqing	Chongqing	20	0.84	0.8	0.78	0.8	0.89	0.9	0.9	0.92	0.97	1.02	1	0.97	0.9	1961~1968
	Fujian	Gutian	20	1.04	0.96	0.92	0.87	0.95	0.94	0.99	1.01	1.03	1.07	1.1	1.07	0.99	1963~1979
	Yunnan	Dianchi	20	0.91	0.89	0.89	0.87	0.9	0.97	0.95	0.96	1.04	1.02	1.01	0.98	0.93	1984~1989
South Subtropical	Guangdong	Guangzhou	20	0.91	0.87	0.84	0.89	0.96	0.99	1.03	1.03	1.05	1.05	1.02	0.97	0.97	1963~1977
Plateau climate zone	Tibet	Baidi	20	0.82	0.82	0.93	0.89	0.85	0.87	0.88	0.89	0.93	0.91	0.86	0.80	0.87	1978~2016
		Lhasa Bridge	20	0.82	0.98	0.81	0.80	0.80	0.84	0.89	0.90	0.93	0.93	0.96	0.89	0.87	1976~2016

Explanation of Wording in This Code

1 Words used for different degrees of strictness are explained as follows in order to mark the differences in executing the requirements in this code:

1) Words denoting a very strict or mandatory requirement:

   "Must" is used for affirmation; "must not" for negation.

2) Words denoting a strict requirement under normal conditions:

   "Shall" is used for affirmation; "shall not" for negation.

3) Words denoting a permission of a slight choice or an indication of the most suitable choice when conditions permit:

   "Should" is used for affirmation; "should not" for negation.

4) "May" is used to express the option available, sometimes with the conditional permit.

2 "Shall meet the requirements of…" or "shall comply with…" is used in this guide to indicate that it is necessary to comply with the requirements stipulated in other relative standards and codes.