

Technical Regulations

Basic Documents No. 2

Volume III – Hydrology

2021 edition

WEATHER CLIMATE WATER



WORLD
METEOROLOGICAL
ORGANIZATION

WMO-No. 49

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EDITORIAL NOTE

The following typographical practice has been followed: Standard practices and procedures have been printed in **bold**. Recommended practices and procedures have been printed in regular font. Notes have been printed in smaller type.

METEOTERM, the WMO terminology database, may be consulted at <https://public.wmo.int/en/meteoterm>.

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NOTE

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GENERAL PROVISIONS

The General Provisions to the Technical Regulations, formerly a part of the present manual, can be found in the publication [Technical Regulations](#) (WMO-No. 49), Volume I – General Meteorological Standards and Recommended Practices.

APPENDIX. PROCEDURES FOR AMENDING WMO MANUALS AND GUIDES THAT ARE THE RESPONSIBILITY OF THE COMMISSION FOR OBSERVATION, INFRASTRUCTURE AND INFORMATION SYSTEMS

Note: This Appendix is currently being revised in accordance with [Recommendation 11 \(INFCOM-1\)](#) – Amendments to the *Technical Regulations, Volume I – General Meteorological Standards and Recommended Practices* (WMO-No. 49) Part I – The WMO Integrated Global Observing System and to the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160).

1. DESIGNATION OF RESPONSIBLE BODIES

The Commission for Observation, Infrastructure and Information Systems (INFCOM) shall designate one of its Standing Committees as the body responsible for each manual within its purview, as well as for the guides associated with that manual. The designated Standing Committee may, in turn, choose to designate one of its Expert Teams as the body responsible for managing changes to all or part of a manual or guide; if no Expert Team is so designated, the Standing Committee in question shall take on the role of the responsible body.

2. GENERAL VALIDATION AND IMPLEMENTATION PROCEDURES

2.1 Proposal for an amendment

An amendment to a manual or a guide managed by INFCOM shall be proposed in writing to the Secretariat. The proposal shall specify the need for, purpose of and requirements associated with the amendment and shall include information regarding a contact point for technical matters.

2.2 Draft recommendation

The body responsible for managing changes to the relevant part of a manual or a guide, supported by the Secretariat, shall validate the stated requirement (unless it is consequential to an amendment to the WMO Technical Regulations) and shall develop a draft recommendation to respond to the requirement, as appropriate.

2.3 Procedures for approval

After the draft recommendation drawn up by the responsible body is validated in accordance with the procedure given in section 7 below, the responsible body should select one of the following amendment approval procedures:

- (a) Simple (fast-track) procedure (see section 3 below);
- (b) Standard procedure (adoption of amendments between INFCOM sessions) (see section 4 below);
- (c) Complex procedure (adoption of amendments during INFCOM sessions) (see section 5 below).

2.4 **Implementation date**

The responsible body should propose an implementation date in order to give WMO Members sufficient time to implement the amendments after the notification date. For procedures other than the simple (fast-track) procedure, if the time between the notification date and the implementation date is less than six months, the responsible body shall document the reasons for this shortened timeframe.

2.5 **Urgent introduction**

Notwithstanding the above-mentioned procedures, as an exceptional measure, the following procedure shall be used to introduce elements in lists of technical details or to correct errors if there is an urgent need to do so:

- (a) A draft recommendation developed by the responsible body shall be validated according to the steps defined in section 7 below;
- (b) The draft recommendation for the preoperational use of a list entry, which can be used in operational data and products, shall be approved by the chair of the responsible body, the chair of the responsible Standing Committee, and the president of INFCOM. A listing of preoperational list entries is kept online on the WMO web server;
- (c) Preoperational list entries shall be submitted for approval by one of the procedures in 2.3 above for operational use;
- (d) Any version numbers associated with the technical implementation should be incremented at the least significant level.

2.6 **Issuing the updated version**

Once amendments to a manual or a guide are adopted, an updated version of that manual or guide shall be published in the languages agreed upon for its publication. The Secretariat shall inform all Members of the availability of a new, updated version of the manual or guide in question on the notification date mentioned in 2.4 above. If the amendments are not incorporated into the published text of the relevant manual or guide at the time of the amendment, there should be a mechanism to publish the amendments at the time of their implementation and to retain a permanent record of the sequence of amendments.

3. **SIMPLE (FAST-TRACK) PROCEDURE**

3.1 **Scope**

The simple (fast-track) procedure shall be used only for changes to components of the manual that have been designated and marked as “technical specifications to which the simple (fast-track) procedure for the approval of amendments may be applied”.

Note: One example of changes which are frequently approved via the simple (fast-track) procedure is the addition of code list tables in the *Manual on Codes* (WMO-No. 306), Volume [1.2](#).

3.2 **Endorsement**

Draft recommendations developed by the responsible body, including the implementation date for the amendments, shall be submitted to the chair of the relevant Standing Committee for endorsement.

3.3 Approval

3.3.1 *Minor adjustments*

Correcting typographical errors in descriptive text is considered a minor adjustment and will be done by the Secretariat in consultation with the president of INFCOM. See Figure 1.



Figure 1. Adoption of amendments to a manual by minor adjustment

3.3.2 *Other types of amendments*

For other types of amendments, the English version of the draft recommendation, including an implementation date, should be distributed to the focal points for matters concerning the relevant manual for comments, with a deadline of two months for the reply. It should then be submitted to the president of INFCOM, who will consult with the president of the Commission for Weather, Climate, Water and Related Environmental Services and Applications (SERCOM) if SERCOM is affected by the change. If endorsed by the president of INFCOM, the change should be passed to the President of WMO for consideration and adoption on behalf of the Executive Council (EC).

3.3.3 *Frequency*

Amendments approved through the simple (fast-track) procedure are usually implemented twice a year: once in May and once in November (see Figure 2).

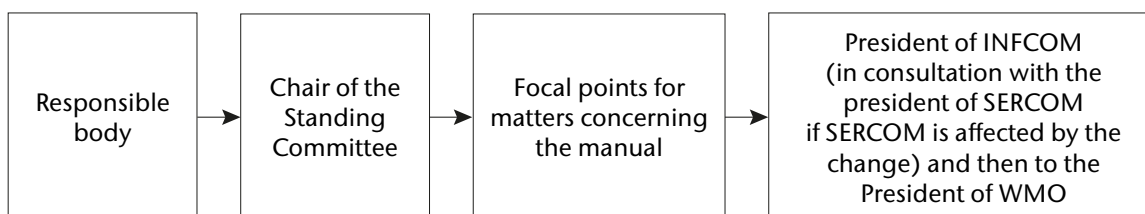


Figure 2. Adoption of amendments to a manual by the simple (fast-track) procedure

4. STANDARD PROCEDURE (ADOPTION OF AMENDMENTS BETWEEN INFCOM SESSIONS)

4.1 Scope

The standard procedure (adoption of amendments between INFCOM sessions) shall be used for changes that have an operational impact on those Members that do not wish to exploit the change but only a minor financial impact, or for changes that are required to implement changes to the *Technical Regulations* (WMO-No. 49), Volume II – Meteorological Service for International Air Navigation.

4.2 **Approval of draft recommendations**

For the direct adoption of amendments between INFCOM sessions, the draft recommendation developed by the responsible body, including an implementation date for the amendments, shall be submitted to the chair of the responsible Standing Committee and the president and co-vice-presidents of INFCOM for approval. The president of INFCOM shall consult with the president of SERCOM if SERCOM is affected by the change. In the case of recommendations in response to changes to the *Technical Regulations* (WMO-No. 49), Volume II – Meteorological Service for International Air Navigation, the president of INFCOM shall consult with the president of the SERCOM.

4.3 **Circulation to Members**

Upon approval of the president of INFCOM, the Secretariat sends the recommendation to all Members in the languages in which the manual is published, including the implementation date for the amendment, for comments to be submitted within two months following the dispatch of the amendments. If the recommendation is sent to Members via electronic mail, there shall be a public announcement of the amendment process including the relevant dates, for example by WMO Operational Newsletter on the WMO website, to ensure that all relevant Members are informed.

4.4 **Agreement**

Those Members not having replied within the two months following the dispatch of the amendments are implicitly considered as having agreed to the amendments.

4.5 **Coordination**

Members are invited to designate a responsible focal point to discuss any comments/disagreements with the responsible body. If the discussion between the responsible body and the focal point cannot result in an agreement on a specific amendment by a Member, this amendment will be reconsidered by the responsible body. If a Member cannot agree that the financial or operational impact of the amendment is minor, the redrafted amendment shall be approved by the complex procedure (adoption of amendments during INFCOM sessions) described in section 5 below.

4.6 **Notification**

Once an amendment is agreed upon by Members, and after consultation with the chair of the responsible Standing Committee, the co-vice-presidents of INFCOM and the president of INFCOM (who should consult with the president of SERCOM if SERCOM is affected by the change), the Secretariat shall simultaneously notify the Members and the members of EC of the approved amendments and their implementation date (see Figure 3).

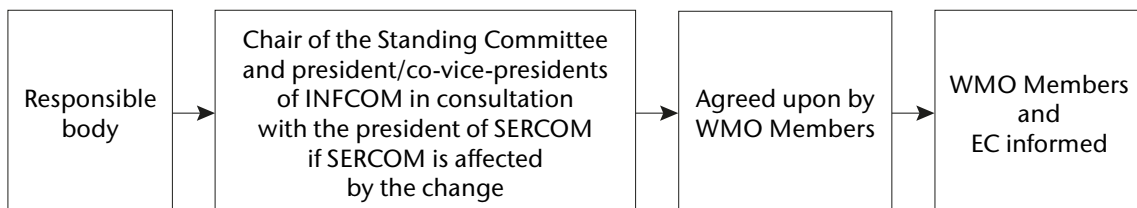


Figure 3. Adoption of amendments between INFCOM sessions

5. **COMPLEX PROCEDURE (ADOPTION OF AMENDMENTS DURING INFCOM SESSIONS)**

5.1 **Scope**

The complex procedure (adoption of amendments during INFCOM sessions) shall be used for changes for which the simple (fast-track) procedure or the standard procedure (adoption of amendments between INFCOM sessions) cannot be applied.

5.2 **Procedure**

For the adoption of amendments during INFCOM sessions, the responsible body submits its recommendation, including the implementation date for the amendments, to the INFCOM Management Group. The recommendation is then passed to the president of SERCOM for consultation, if SERCOM is affected by the change, and to an INFCOM session that shall be invited to consider the comments submitted by the presidents of the technical commissions. The document for the INFCOM session shall be distributed no later than 45 days before the opening of the session. Following the INFCOM session, the recommendation shall then be submitted to EC at its session for a decision (see Figure 4).

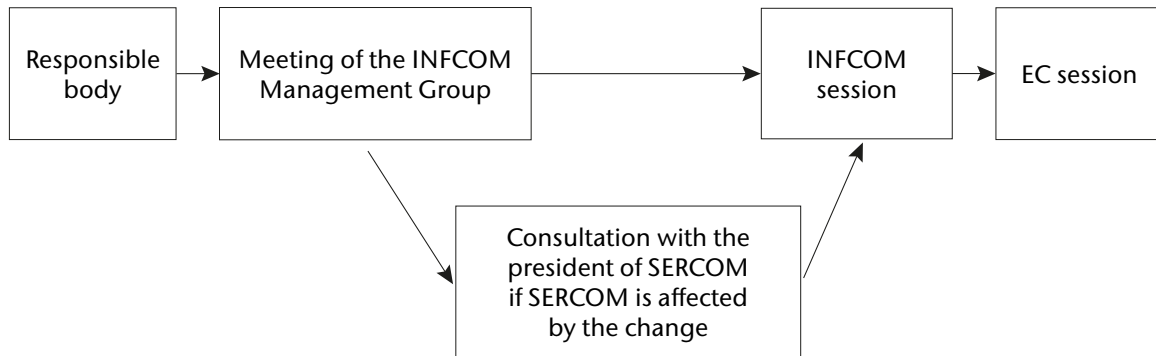


Figure 4. Adoption of amendments during INFCOM sessions

6. **PROCEDURE FOR CORRECTING THE CONTENTS OF A MANUAL**

6.1 **Correcting errors in items within a manual**

Where a minor error in the specification of an item that defines elements within a manual is found, for example, a typing error or an incomplete definition, the item shall be amended, and the manual shall be republished. Any version numbers associated with items edited as a result of the change should be incremented at their lowest level of significance. If, however, the change has an impact on the meaning of the item, a new item should be created and the existing (erroneous) item marked as deprecated. This situation is considered a minor adjustment according to 3.3.1 above.

Note: An example of an item for which this type of change applies would be a code list entry for the Table Driven Code Forms or the WMO Core Metadata Profile in which the description contains typographical errors that can be corrected without changing the meaning of the description.

6.2 **Correcting an error in the specification of how conformance with the requirements of the manual can be checked**

If an erroneous specification of a conformance-checking rule is found, the preferred approach is to add a new specification using the simple (fast-track) procedure or the standard procedure (adoption of amendments between INFCOM sessions). The new conformance-checking rule should then be used instead of the old rule. An appropriate explanation shall be added to the description of the new conformance-checking rule to clarify the practice along with the date of the change.

Note: An example of such a change would be correcting a conformance-checking rule in the WMO Core Metadata Profile.

6.3 **Submission of corrections of errors**

Changes involving corrections to errors shall be submitted through the simple (fast-track) procedure.

7. **VALIDATION PROCEDURE**

7.1 **Documentation of need and purpose**

The need for and purpose of the proposal for changes should be documented.

7.2 **Documentation of result**

This documentation shall include the results of the validation testing of the proposal as described in 7.3 below.

7.3 **Testing with relevant applications**

For changes that have an impact on automated processing systems, the extent of the testing required before validation should be decided by the responsible body on a case-by-case basis depending on the nature of the change. Changes involving a relatively high risk and/or impact on the systems should be tested using at least two independently developed tool sets and two independent centres. In these cases, the results should be made available to the responsible body with a view to verifying the technical specifications.

DEFINITIONS

Introductory note. The following terms, when used in the present *Technical Regulations* (WMO-No. 49), Volume III, have the meanings given below. Some of these terms (identified by an asterisk) are defined in the *Technical Regulations* (WMO-No. 49), Volume I, or in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) which constitutes Annex VIII to the WMO Technical Regulations, but it was considered desirable, for the convenience of the reader, to repeat the definitions in this volume.

Alarm level. Water level at, or approaching, flood stage, which is considered to be dangerous and at which warnings should be commenced.

Aquifer. Geological formation capable of storing, transmitting and yielding exploitable quantities of water.

Basin or Catchment area. An area having a common outlet for its surface run-off.

***Climatological station.** A station from which climatological data are obtained.

Climatological station for hydrological purposes. A climatological station set up in a drainage basin specifically to augment the existing climatological network in order to meet hydrological requirements.

Discharge. The volume of water flowing through a river (or channel) cross-section per unit time.

Drainage basin. (See Basin or Catchment area).

***Elevation.** The vertical distance of a point or level, on or affixed to the surface of the Earth, measured from mean sea level.

Estuary. Broad portion of a stream near its outlet to a sea, lake or sabkha.

Flood.

- (1) Rise, usually brief, in the water level of a stream or water body to a peak from which the water level recedes at a slower rate.
- (2) Relatively high flow as measured by stage height or discharge.

Flash flood. Flood of short duration with a relatively high peak discharge.

Forecast (warning) lead time. Interval of time between the issuing of a forecast (warning) and the expected occurrence of the forecast element.

Gauge datum. Vertical distance between the zero of a gauge and a certain datum level.

Groundwater level. Elevation of the water table or the piezometric surface of an aquifer at a certain location and time.

Groundwater station. A station at which data on groundwater are obtained on one or more of the following elements: water level, water temperature and other physical and chemical properties of water, and rate and volume of abstraction and/or recharge.

Hydrograph. Graph showing the variation in time of some hydrological data, such as water stage, discharge or velocity, and sediment load.

Hydrological drought. A period of abnormally dry weather sufficiently prolonged to give rise to a shortage of water as evidenced by below-normal streamflow and lake levels and/or the depletion of soil moisture and a lowering of groundwater levels.

- Hydrological forecast.** An estimation of the magnitude and time of occurrence of future hydrological events for a specified period and for a specified locality.
- Hydrological observation.** The direct measurement or evaluation of one or more hydrological elements, such as stage, discharge, water temperature, and so forth.
- Hydrological observing station.** A place where hydrological observations or climatological observations for hydrological purposes are made.
- Hydrological warning.** Emergency information on an expected hydrological phenomenon which is considered to be dangerous.
- Hydrometric station.** A station at which data on water in rivers, lakes or reservoirs are obtained on one or more of the following elements: stage, streamflow, sediment transport and deposition, water temperature and other physical properties of water, characteristics of ice cover and chemical properties of water.
- Lateral inflow.** Inflow of water to a river, lake or reservoir along any reach from the part of the catchment adjacent to the reach).
- Long-term hydrological forecast.** A hydrological forecast for a period extending beyond 10 days from the time of issue of the forecast.
- Medium-term hydrological forecast.** A hydrological forecast for a period ending between 3 and 10 days from the time of issue of the forecast.
- *Meteorological forecast (Forecast).** A statement of expected meteorological conditions for a specified time or period, and for a specified area or portion of air space.
- *Meteorological observation (Observation).** The evaluation or measurement of one or more meteorological elements.
- Pluvial flood or ponding flood.** A flood which results from rainwater ponding at or near the point where it falls because it is falling faster than the drainage system (natural or artificial) can carry it away.
- Quality assurance.** Activities undertaken to instil confidence that quality requirements have been met. It involves the systematic monitoring and evaluation of the processes associated with the generation of a product or service.
- Quality control.** Activities undertaken to ensure that quality requirements have been fulfilled prior to the dissemination of a product or the delivery of a service.
- Rating curve.** A curve showing the relation between stage and discharge of a stream at a hydrometric station.
- Seasonal hydrological forecast.** A hydrological forecast for a season (usually covering a period of several months or more).
- Short-term hydrological forecast.** A hydrological forecast for a period ending up to 3 days from the time of issue of the forecast.
- Snow courses.** A line laid out and permanently marked, along which snow is sampled, or its depth measured, at appropriate times at stations separated by definite distances.
- Snow cover.** Snow accumulated on the ground.
- Snow depth.** The vertical distance between the surface of a snow layer and the ground, the layer being assumed to be evenly spread over the ground which it covers.

Stage. The elevation of the free water surface of a water body relative to a datum level.

Storm surge. Rise in sea or estuary water level caused by the passage of a low pressure centre.

Streamflow. A general term for water flowing in a watercourse.

Uncertainty. Estimate of the range of values within which the true value of a variable lies.

Water equivalent of snow cover. Vertical depth of the water layer which would be obtained by melting a snow cover.

Water stage. (See Stage).

Water supply forecast. A statement of the expected volume of available water with associated time distribution and probabilities, whenever feasible for a specified period and for a specified area.

CHAPTER 1. FUNCTIONS AND RESPONSIBILITIES OF HYDROLOGICAL SERVICES

1.1 General

Each Member shall ensure that a national capacity exists to acquire, store and disseminate the water-related data and information required for sustainable development and management of its water resources, and for the mitigation of water-related hazards.

Note: Detailed guidance on the acquisition of water-related data and hydrological information is provided in the [Guide to Hydrological Practices](#) (WMO-No. 168), Volume I, Chapters 2 to 7.

1.2 Organization

1.2.1 Members should ensure efficient and effective coordination and communication among the providers and users of water-related data and hydrological information, through arrangements appropriate to their system of government and socio-economic and geographic characteristics.

1.2.2 Where several agencies and/or levels of government have separate responsibilities for providing and using information, Members should ensure clearly established responsibilities and relationships, and good coordination of their activities using appropriate administrative and legal arrangements.

Note: Examples of methods for organizing the acquisition of water-related data and hydrological information are provided in the [Guidelines on the role, operation and management of National Hydrological Services](#) (WMO-No. 1003) and in the [Guidelines on the Role, Operation and Management of National Meteorological and Hydrological Services](#) (WMO-No. 1195).

1.3 Functions

In general, Members should ensure that the routine functions of National Hydrological Services include:

- (a) Coordinating the agencies which have responsibilities for acquiring and/or using water-related data and hydrological information;
- (b) Establishing the requirements of existing or possible future users of water-related data and hydrological information, including the requirements of other organizations that are collecting environmental and environmental-impact data in relation to land use and climate change;
- (c) Defining the standards (accuracy, precision, timeliness, accessibility, and so forth) of the data which are implied by those requirements;
- (d) Designing, establishing and operating hydrometric networks to measure the various types of data required. Both "use-specific" and "basic" networks may be needed, which may be complementary or even overlapping, and which should be integrated;
- (e) Evaluating the adequacy of the existing network to ensure that the data and information collected meet the requirements of the users;

- (f) Establishing a quality management system that includes staff qualifications, training and development, documentation of data collection and analysis methods and procedures, procurement and calibration of instrumentation, and review and approval of reports;

Note: Detailed guidance on the provision of meteorological, hydrological and climatological services within the framework of ISO 9001:2015, *Quality management systems — Requirements* is provided in the [Guide to the Implementation of Quality Management Systems for National Meteorological and Hydrological Services and Other Relevant Service Providers](#) (WMO-No. 1100).

- (g) Developing methods for extrapolating data from sites at which measurements have been made to points or regions for which they are intended to be representative;
- (h) Collecting data, and maintaining quality control of the data collection process by inspecting and auditing both field installations and field practice;
- (i) Assembling water-related data and hydrological information generated by non-governmental, international and private sector organizations, and ensuring their future accessibility;
- (j) Transmitting, processing and archiving data, and maintaining control of the quality and security of the archived data;
- (k) Making the data accessible to users, when, where and in the form they require. For example, this may include:
 - (i) Information about the current hydrological conditions within a basin, region or the country as a whole;
 - (ii) Hydrological data and statistics, for example, annual summary statistics;
 - (iii) Reports on water resources, in which data are comprehensively analysed. This may include media such as hydrological atlases or databases in geographical information systems;
 - (iv) Informative or educational material for use by the general public, the news media or schools;
 - (v) Calculations of the risk of hydrological events occurring, for example, in the form of return periods for floods of certain magnitudes;
 - (vi) Support for global data exchange, international programmes and projects;
- (l) Informing potential users of the information that is available to them, and assisting them to make the best use of it;
- (m) Adapting or developing new methods and technology related to:
 - (i) Network design;
 - (ii) Instrumentation and methods of observation;
 - (iii) Data transmission and processing;
 - (iv) Hydrological analysis and forecasting;
 - (v) Data analysis, interpretation and presentation;
- (n) Carrying out research into hydrological and related processes, in order to assist the user in interpreting and understanding the data;

- (o) Producing and disseminating hydrological forecasts and warnings;
 - (p) Collaborating with agencies that acquire water-related or other relevant information, such as water quantity and quality, sediment, hydrogeological, water use, topographic and land use, or meteorological information;
 - (q) Participating with foreign water-sector agencies in international programmes and projects;
 - (r) Furnishing hydrological information for inclusion in countries' periodic reports on the state of the environment and water accounting;
 - (s) Undertaking water resources assessment studies for development and sustainability purposes;
 - (t) Participating in the planning, development and management of water resources projects.
-

CHAPTER 2. HYDROLOGICAL OBSERVATION NETWORKS

2.1 General

2.1.1 **Members shall undertake hydrological observations by establishing, operating and maintaining networks of hydrological observing stations, observing devices, observation methods, procedures and communication links.**

2.1.2 **Members shall undertake hydrological observations according to the national requirements, and update them as necessary.**

2.1.3 Each Member should ensure that the operational methods used for data transmission are reliable under adverse conditions and that potential critical points of failure are minimized.

2.2 Hydrological monitoring programme

Members should establish and implement hydrological monitoring programmes that consist of a number of interrelated components:

- (a) Water legislation and policies;
- (b) Programme objectives;
- (c) Programme design;
- (d) Field activities;
- (e) Laboratory activities where required;
- (f) Data management;
- (g) Data analysis;
- (h) Quality assurance programme;
- (i) Interpretation and report generation;
- (j) Information utilization and decision-making.

2.3 Monitoring objectives

Each Member should define the objectives of its hydrological monitoring programme in terms of the products to be delivered, in accordance with the current legislation, policies and priorities, and with respect to the existing infrastructure and resources.

2.4 Networks of hydrological observing stations

Note: Detailed guidance on design of networks is given in the *Guide to Hydrological Practices* (WMO-No. 168), Volume I, Chapter 2.

2.4.1 Each Member shall establish in its territory a network of hydrological observing stations.

Note: The design of hydrometric networks may be based on the concept of principal and secondary stations as outlined in the *Guide to Hydrological Practices* (WMO-No. 168), Volume I, Chapter 2.

2.4.2 Each Member should ensure that the network of hydrological observing stations is adequate to permit the assessment, to an accuracy consistent with its purpose, of the elements of the hydrological cycle and other hydrological characteristics of any region.

2.4.3 In planning networks of hydrological observing stations, each Member should take into account the requirements of global or regional studies or programmes.

2.4.4 In planning networks of hydrological observing stations for international drainage basins, each Member should take into account the requirements of the various Members concerned.

2.4.5 Where required, Members should make observations of precipitation, evapotranspiration, soil moisture and the water equivalent of snow for hydrological purposes, in accordance with the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160).

2.5 Location of hydrological observing stations

2.5.1 Members should locate each station at a site which enables stationarity, correct exposure and functioning of the instruments, and accurate instrumental and non-instrumental observations.

Note: Detailed guidance is given in the *Guide to Hydrological Practices* (WMO-No. 168), Volume I, Chapter 2.

2.5.2 Members should locate each station at a place and under an arrangement which will provide for the continued operation of the station for at least 10 years, unless it serves a specific purpose which justifies its functioning for a shorter period.

2.5.3 Members should locate each climatological station for hydrological purposes in accordance with the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160).

2.6 Identification of hydrological observing stations

Members should identify each hydrological observing station by a unique identifier, its name and geographical coordinates and, where applicable, by the name of the river and major river basin, lake, reservoir or aquifer on or in which it is situated.

2.7 Information relating to hydrological observing stations

2.7.1 Each Member shall maintain an up-to-date directory of its hydrological observing stations, containing the following information for each station, where applicable:

- (a) Name of river basin, name of river, lake, reservoir or aquifer, name of station and its geographical coordinates;
- (b) Elevation of reference datum of water level observations and/or elevation of the station and the geodetic system of reference;

- (c) Elevation of the surface of the ground at the well used for groundwater measurement;
- (d) Type of station (stream gauging, lake gauging, groundwater observations, soil moisture, precipitation, snow, evaporation, sediment or water quality);
- (e) Elements observed;
- (f) Instrumentation and description of the observing programme;
- (g) Area of the catchment upstream of the station in square kilometres (km²);
- (h) Information on any artificial control and regulation of streamflow or water level, and on conditions relating to ice;
- (i) A station history containing dates of beginning, closing or interruption of records, changes in the name of the station, changes in instrumentation or observing programme, changes in the units of recording, changes in reference datum, changes in position (coordinates) and information on water abstractions, recharges and returns excluded or included in the observations, as the case may be;
- (j) The name of the operating and supervising organization or institution;
- (k) Information on characteristics of the catchment or groundwater basin, including elevation, topography, geology, hydrogeology, vegetation, urban development and principal water resources and drainage development.

2.7.2 Where observations are made available through the WMO Hydrological Observing System (WHOS), Members should follow the provisions specified in the [Manual on the WMO Integrated Global Observing System](#) (WMO-No. 1160).

2.8 Supervision of hydrological observing stations

Each Member shall arrange for its hydrological observing stations to be inspected and audited periodically to ensure the correct functioning of instruments and the maintenance of a high standard of observations.

Notes:

- (a) Detailed guidance is given in the [Guide to Hydrological Practices](#) (WMO-No. 168), Volume I, Chapter 2;
- (b) These inspections are independent of routine inspection and maintenance of instruments and stations essential to efficient day-to-day working;
- (c) These inspections include checking of the gauge datum.

2.9 Composition of observations

At a hydrological observing station, Members shall make observations of at least one of the following elements:

- (a) Water level (stage) of a river, lake, reservoir or groundwater body;
- (b) Discharge (streamflow);
- (c) Precipitation;
- (d) Sediment transport and/or deposition;
- (e) Temperature and other physical properties of water;
- (f) Characteristics and extent of ice and snow cover;

- (g) **Chemical and biological properties of water;**
- (h) **Rate and volume of abstraction or recharge;**
- (i) **Soil moisture.**

2.10 **Observing and reporting programme for hydrological observing stations**

Note: In addition to the regulations in this section, detailed guidance on observing programmes is given in the [Guide to Hydrological Practices](#) (WMO-No. 168), Volume I, Chapter 2.

2.10.1 Members should make observations of parameters for hydrological purposes at regular intervals that are appropriate for the elements and purposes, and consistent with the temporal scale of response of the system (basin) and the variability of the river or lake surface level.

2.10.2 Members should generally ensure uniformity in observation time within a catchment area.

2.10.3 Members should prescribe the reporting interval of river, lake and reservoir stages to meet the intended operational use, having regard to adequate definition of hydrographs under flood or variable control conditions and possible interferences or aliasing from lake seiche, controlled flow, and so forth.

2.10.4 When sudden and dangerous increases in river levels occur, Members should make and report observations as soon as possible without regard to the usual time of observation, to meet the intended operational use.

2.10.5 Members should ensure that hydrological information for international purposes is in the appropriate code format or open markup language in accordance with any bilateral or multilateral agreement.

Note: The regulations governing exchanges in international code is specified in the [Manual on Codes](#) (WMO-No. 306), Volume I.3.

2.11 **Equipment and methods of observation**

Note: In addition to the regulations in this section, detailed guidance on equipment and methods of observation is given in the [Guide to Hydrological Practices](#) (WMO-No. 168), Volume I, Chapters 2 to 7.

2.11.1 **Each Member shall ensure that the measurements and observations of the hydrological variables are accurate enough to meet the needs of hydrology.**

Note: Detailed guidance is given in the [Guide to Hydrological Practices](#) (WMO-No. 168), Volume I, Chapter 2.

2.11.2 Each Member should equip and maintain its stations with calibrated instruments.

2.11.3 Each Member should compile its own set of standard operating procedures that are consistent with the WMO Technical Regulations and ISO standards, to cover its operations regarding the following items relevant to measuring equipment and techniques:

- (a) Specifications of facilities, equipment and procedures to be used for the calibration of current meters and other depth and velocity measuring instruments;
- (b) Devices for the measurement of water levels;

- (c) The functional requirements of the equipment, excluding bankside cableway systems, used in the measurement of liquid flow in open channels for sounding (by direct method), and suspending the measuring equipment (for example, current-meter or sediment sampler) at the points of measurement;
- (d) Operational requirements, construction, calibration and maintenance of velocity measurement instruments;
- (e) Functional requirements for the measurement of discharge using weirs and flumes;
- (f) Conditions and requirements for the use of dilution methods for measurement of discharge in open channels;
- (g) Equipment and functional requirements for the use of acoustic Doppler profiler methods for discharge measurement;
- (h) The establishment and operation of a hydrometric station for measuring discharge;
- (i) Methods of determining the stage-discharge relation (rating curve) for a station;
- (j) Methods of determining stage-velocity-discharge relations for a station (surface velocity radar methods and side-looking Acoustic Doppler Current Profiler (ADCP) are used for these techniques);
- (k) Method for the determination (estimation) of sediment transport rates by conventional and surrogate techniques.

Note: Detailed guidance is given in the *Guide to Hydrological Practices* (WMO-No. 168), Volume I, Chapters 2 to 7.

2.11.4 Members should include in hydrological observations a determination of uncertainty which should be communicated with the data.

2.11.5 Members should make measurements of the depth and water equivalent of snow cover in permanently marked areas or snow courses where snow surveys are taken every year. Those areas or snow courses should be located to provide a reliable index of the water equivalent of the snow cover over a great part of a river basin.

2.11.6 Each Member should have access to a sediment laboratory which is equipped for two principal functions:

- (a) The determination of suspended-sediment concentrations of samples collected from streams;
- (b) The determination of the particle size distribution of suspended sediment, stream-bed material and reservoir deposits.

2.12 **Collection, processing and publication of hydrological data**

Note: Detailed guidance regarding the collection, processing and publication of hydrological data is given in the *Guide to Hydrological Practices* (WMO-No. 168), Volume I, Chapters 9 and 10.

2.12.1 **Each Member shall collect and preserve its hydrological data and records.**

2.12.2 Members should establish ongoing processes for preserving all hydrological data at risk of being lost, due, for example, to deterioration of the medium or obsolescence of data format, and for digitizing current and past data into computer compatible formats for easy access.

Note: Detailed guidance is given in *Guidelines for Hydrological Data Rescue* (WMO-No. 1146).

2.12.3 Each Member should maintain in its archives an up-to-date inventory of the hydrological data available in its territory.

2.12.4 Members should select the time units used in processing hydrological data for international exchange from the following:

- (a) The Gregorian calendar year;
- (b) The months of this calendar;
- (c) The mean solar day, from midnight to midnight, according to the zonal time, when the data permit;
- (d) Other periods by mutual agreement in the case of international drainage basins or in the case of drainage basins in the same type of region.

2.12.5 Members should ensure that sums or averages of all or most of the following data from a selection of hydrological observing stations can be computed for each month and for the year:

- (a) River, lake, reservoir or groundwater water levels;
- (b) Discharge (streamflow);
- (c) Sediment transport;
- (d) Water temperature;
- (e) Chemical properties of water.

2.12.6 Members should ensure that for selected surface water stations the following characteristics for each year can be processed:

- (a) Maximum instantaneous and minimum daily mean values of water stages and streamflow;
- (b) Statistical frequency of mean daily water stages and/or mean daily discharges;
- (c) Mean weekly suspended-sediment discharges;
- (d) Measured values of the concentration of chemical constituents in streams.

2.12.7 Members should ensure that for selected groundwater stations the following characteristics for each year are processed:

- (a) Maximum and minimum values of groundwater levels;
- (b) Statistical frequency of mean daily groundwater levels;
- (c) Measured values of the concentration of chemical constituents in the groundwater.

2.12.8 Members should be able to compute long-term annual and monthly averages of some elements for selected hydrological observing stations within their territory where there are at least 10 years of continuous records.

2.12.9 Each Member should ensure the regular publishing of hydrological data in an appropriate form, including details of each hydrological observing station indicating, where applicable:

- (a) Name of river, lake, reservoir or aquifer, name of station and geographical coordinates;
- (b) Elevation of reference datum for observations in metres;
- (c) Area of the catchment above the station in square kilometres (km²);
- (d) Details of observing methods and instrumentation characteristics;
- (e) Period of record;
- (f) Information on principal upstream diversions and artificial controls;
- (g) Hydrological data and their statistical characteristics, where applicable.

2.12.10 **Whenever long-term averages are published, Members shall indicate the period to which they refer.**

2.12.11 Except where WMO practices indicate otherwise, Members should use the International System of Units (SI units), as defined by the International Organization for Standardization (ISO), in scientific publications and other scientific documents.

Note: Guidance on the use of these units is given in ISO 80000-1:2009, *Quantities and units*.

2.12.12 Recommended symbols and units used for hydrological purposes should be as given in the *WMO Manual for Hydrological Symbols and Units* (in preparation).

2.13 **Safety procedures**

2.13.1 **Each Member shall ensure that proper safety procedures are specified, documented and utilized in all its operations. Members shall ensure that these procedures meet all the requirements of the country or territory, including legal, health and safety codes.**

2.13.2 Each Member should establish a handbook for national safety procedures which stresses precautions and practices that are specific to the conditions in the country or territory concerned.

Note: In addition to the regulations in this section, Members are referred to the [Guide to Hydrological Practices](#) (WMO-No. 168), Volume I, Chapter 8, which contains detailed guidance on safety procedures.

CHAPTER 3. HYDROLOGICAL FORECASTS AND WARNINGS

3.1 **General**

Each Member shall ensure, to the extent possible, that hydrological forecasts and warnings are issued for protection of its populace from hazardous hydrological conditions and for purposes of water management operations.

Note: Detailed guidance regarding the principles and practice of hydrological forecasting is given in the [Guide to Hydrological Practices](#) (WMO-No. 168), Volume II, Chapter 7, [Manual on flood forecasting and warning](#) (WMO-No. 1072) and [Manual on Low-flow Estimation and Prediction](#) (WMO-No. 1029).

3.2 **Organization of the hydrological forecast and warning service**

3.2.1 The hydrological forecasting service should be organized in such a way as to ensure efficient coordination and communication, including data collection and exchange of hydrological data, among all entities involved and with those responsible for the provision of meteorological data and forecasts.

3.2.2 **Where the hydrological and the meteorological forecasting and warning services are delivered by separate organizations, Members shall ensure that their responsibility and authority are clearly defined.**

3.3 **User focus**

3.3.1 Members should identify users and understand their needs and requirements for hydrological forecasts and warnings in their decision-making practices. Users' needs and requirements should be reflected in the hydrological forecast products, their lead time, associated uncertainty, issuance frequency, form of communication, and so forth.

3.3.2 Close coordination should be maintained with users, and effective feedback mechanisms established.

3.3.3 Members should ensure that the services provided by the forecasting system are continually promoted in order to broaden the number and type of users, which may vary depending on the hydrological conditions.

3.4 **Forecasting and warning programme**

3.4.1 ***Types of forecasts, warnings and advisories to be issued***

3.4.1.1 Based on users' needs and requirements, hydrological forecast products of various kinds and lead times should be delivered by Members. The products should reflect various forecast ranges:

- (a) Flash flood forecasts and warnings for periods of up to several hours;
- (b) Short-term hydrological forecasts and warning that are generally understood to cover periods of up to 3 days;

- (c) Medium-range hydrological forecasts and warnings providing lead times of up to 10 days;
- (d) Sub-seasonal to seasonal forecasts and outlooks beyond 10 days, providing descriptions of hydrological conditions for given periods.

Note: The defined temporal extents of hydrological forecast and warning ranges are indicative and differ for individual basins based on their response time and the persistence of the effect of initial hydrological conditions.

3.4.1.2 The basic hydrological elements for which forecasts should be issued are as follows:

- (a) Water levels (river/lake stage) for specified times; also, velocity and discharge where needed for navigation, water supply and/or other requirements;
- (b) In flood periods, and for each event, the time at which the water level is expected to rise above the alarm level, the peak stage (and possibly discharge and/or velocity) and its expected time of occurrence, and the duration for which the water level is expected to stay above the alarm level;
- (c) Ice conditions on rivers, lakes and reservoirs;
- (d) Volume and time distribution of run-off for various periods of time (periods of high and low flows, month, season, year);
- (e) Hydrological drought conditions (for example, extremely low water stages or discharges according to long-term values);
- (f) Storm surges and wave heights in estuaries, coastal zones, large lakes and reservoirs;
- (g) Any problematic or important water quality parameters (such as groundwater salinity);

Whenever feasible, the associated probabilities of the above-listed elements should be provided.

3.4.1.3 In order for hydrological forecasts and warnings to be understood and expected as widely as possible in a community, the following hydrological information should be provided on a routine basis:

- (a) Information regarding the current hydrological situation (including, as and if appropriate, water stages, discharges and water quality parameters for rivers, estuaries, coastal zones, lakes and reservoirs; ice conditions; groundwater levels; soil moisture; precipitation; water equivalent of snow cover and snow cover extent);
- (b) The information described above should be accompanied, as much as possible, by references to normal values and normal variation, at the corresponding time of the year, in order to provide context that helps understanding of the meaning of the observations;
- (c) Assessment of conditions which are conducive to high levels and run-off;
- (d) Assessment of conditions which may be indicative of future drought conditions.

3.4.2 **Early warning system**

3.4.2.1 Members should provide hydrological warnings through the implementation of an early warning system.

3.4.2.2 Warning information should incorporate, to the extent possible, information about impacts of hydrological hazards on individuals and communities, including on infrastructure and other property.

3.5 **Data requirements**

3.5.1 **Collection and transmission of data**

3.5.1.1 Members should design networks of hydrological observing stations in such a way that they provide observational data required for the preparation of the hydrological forecasts, warnings and advisories listed in [3.4.1](#).

3.5.1.2 Each Member should arrange for the timely collection and distribution of the data required for the preparation of the forecasts, warnings and advisories listed in [3.4.1](#).

3.5.1.3 For the operation of hydrological forecasting and warning services, Members should ensure the availability of hydrological observations, meteorological observations and meteorological forecasts at appropriate resolutions and frequency.

3.5.2 **Meteorological observations and forecast data**

Desirable characteristics of meteorological observations and forecast data for hydrological forecasting purposes should be as indicated in [5.2](#) and [5.3](#).

3.6 **Selection of forecasting techniques**

In selecting a forecasting technique, the hydrological forecasting service should take into account the forecast needs (hydrological variable, forecast lead time), the characteristics of the system, the data available (and their availability in real time or at adequate latencies), the resources available and, among others, the experience derived from investigations and intercomparison of techniques. A parsimonious approach should be preferred, especially in hydrological forecasting services in their initial stages of development, with priority given to simple low data-demanding models/techniques of low computational burden.

Note: Information on forecasting techniques is given in the [Guide to Hydrological Practices](#) (WMO-No. 168), Volume II, Chapter 7, and [Manual on flood forecasting and warning](#) (WMO-No. 1072).

3.6.1 **Use of quantitative precipitation forecasts in forecasting with hydrological models**

3.6.1.1 Hydrological forecasting should be based on whatever combination of observed and forecast rainfall provides the most timely and accurate forecast.

3.6.1.2 The decision to use a quantitative precipitation forecast (QPF) in a hydrological forecast should be an operational decision based on the following hydrological information relevant to the forecast event:

- (a) The probable error in the QPF as regards volume, location and timing, and considering the optimum observed data products for the forecasting ranges;
- (b) How such errors propagate through the hydrological forecasting technique and affect the accuracy of the hydrological forecast;
- (c) How the user of the forecast is affected by varying forecast lead time and by varying levels of forecast accuracy.

3.6.2 **Forecast adjustment**

As new information becomes available, hydrological forecast adjustment should be performed in such a manner as to make full use of the forecaster's knowledge and judgement. Where available,

automated adjustment techniques should be used to aid the forecast adjustment process. The possibility of running hydrological models in updating mode, or applying data assimilation techniques, stochastic forecast correction or other adjustment techniques should be explored.

Note: Information on forecast adjustment techniques is given in the *Guide to Hydrological Practices* (WMO-No. 168), Volume II, Chapter 7, and *Manual on Flood Forecasting and Warning* (WMO-No. 1072).

3.6.3 **Uncertainty in hydrological forecasts**

3.6.3.1 **The hydrological forecasting service shall establish administrative regulations (for example, develop and/or follow guidelines) concerning the manner in which hydrological forecasts, and their probable errors, are expressed.**

3.6.3.2 The service should also undertake whatever educational activities are needed to ensure that the forecast user understands not only the forecast, but also its probable error.

3.7 **Flash floods**

3.7.1 **In areas where flash floods are a significant risk to human life, the hydrological forecasting service shall provide flash flood forecasts and warnings, based on at least an assessment of initial hydrological conditions and expected precipitation intensities. To enable this, the hydrological forecasting service shall ensure:**

- (a) **Rapid transmission of field observations to the forecast office;**
- (b) **Rapid computation of the forecast;**
- (c) **Rapid transmission of the forecast to the ultimate user.**

3.7.2 The service should prioritize the provision of generalized flash flood warnings where the preparation of refined, site-specific forecasts causes unacceptable delay.

3.8 **Pluvial flooding (surface water flooding)**

3.8.1 In areas where pluvial flooding and lateral inflow occur, the rainfall intensity which is likely to cause flooding should be ascertained.

3.8.2 Warnings should be issued when such intensities are being experienced or considered to be imminent, taking into account antecedent conditions, current QPF, and so forth.

3.8.3 The hydrological forecasting service should ensure that all concerned, including the users, understand the difference between pluvial flooding and flooding caused by rivers and storm surges.

3.9 **Dam breaks and glacial lake outbursts**

3.9.1 Members should assess the risk of flooding from dams and glacial lakes in their territory.

3.9.2 For those dams and glacial lakes whose failure would cause extensive property damage and/or loss of life, advance computation should be made of the downstream flood profile and of the alarm levels, based on various types of assumed failures including the worst possible case.

3.9.3 Preparations should be made for these data to be readily available operationally to the relevant agencies that are primarily responsible for the protection of life and property in the event of a failure.

3.10 **Debris flows and debris flooding**

In high-energy settings (such as steep mountain catchments) where debris flows or debris flooding have been identified to be a significant risk to downstream infrastructure, populations or resources, Members should develop an early warning and alert service for such events.

3.11 **Estuaries and coastal zones including storm surges**

3.11.1 Where the land area adjacent to an estuary or a coast is subject to damage by flooding or where extreme stages and/or discharges in an estuary affect navigation activities, the hydrological forecasting service should issue forecasts of stages and/or discharges in the estuary. In addition, forecasts of stages and/or discharges in an estuary are typically required to set the boundary condition of a hydraulic model for riverine flood forecasting.

3.11.2 In areas where storm surges may occur with significant impacts on lives and livelihoods to be a problem, the hydrological forecasting service should make use of meteorological service products and concentrate on providing generalized storm surge warnings where the preparation of refined, site-specific forecast causes unacceptable delay.

Note: A service that lacks the resources to apply a dynamic routing procedure to an estuary may obtain adequate results by using an empirical graphical relationship involving upstream discharge, open sea surge and estuary stage.

3.12 **Urban flooding**

In urban areas, the hydrological forecasting service should have the capability to provide warnings based on QPF that can be compared to the design storm for the urban drainage systems and any related subsurface structures.

3.13 **Groundwater flooding**

The hydrological forecasting service should determine which areas are prone to groundwater flooding. The expected effects of groundwater flooding on subsurface and surface structures should be assessed, where appropriate.

3.14 **Low flow forecasts**

3.14.1 **Water supply forecasts**

Where needed, the hydrological forecasting service should make medium-term and sub-seasonal to seasonal hydrological forecasts to enable the efficient operation of water supply systems. Usually, such forecasts should take account of future weather and therefore, in general, they should be given in probabilistic terms.

Note: Information on techniques used for making water supply forecasts using stochastic inputs to continuous streamflow models or probabilistic analyses of model output based on historical data is given in the [Guide to Hydrological Practices](#) (WMO-No. 168), Volume II, Chapter 7, and [Guidelines on Seasonal Hydrological Prediction](#) (WMO-No. 1274).

3.14.2 ***Water level forecasts***

Under sustained low flow conditions, short- and medium-term hydrological forecasts of water level (and water depths) become important. The hydrological forecasting service should make such forecasts, to enable the efficient operation of the waterway, especially in the case of navigable rivers. The supply of water to drinking water treatment plants or to cooling systems of power stations may also require forecasts of water level (and head) at the location of pumping stations.

3.14.3 ***Hydrological drought forecasts***

The hydrological forecasting service should regularly assess the conditions that may indicate the onset of a period of hydrological drought and should publish its assessments of the situation on a regular basis.

3.15 ***Cold region phenomena***

3.15.1 ***Snow monitoring***

3.15.1.1 In areas where snow occurs, the hydrological forecasting service should ensure that snow is taken into account when producing hydrological forecasts and warnings.

3.15.1.2 Reporting procedures should ensure that the character of precipitation (snow or rain) as well as its amount are reported to the forecaster.

3.15.1.3 In accessible portions of river basins, snow surveys should be made as often as necessary to maintain a continuing quantitative assessment of the snow cover and the situation of water equivalent of snow cover.

3.15.1.4 Satellite remote sensing products for snow cover and water equivalent of snow cover should be considered, as well as in situ measurements.

3.15.2 ***Snowpack modelling***

Where required for decision-making on seasonal meltwater uses or hazard mitigation, Members should carry out snow cover and snowmelt modelling as components of forecasting techniques to account for snow dynamics and associated meltwater outflows.

3.15.3 ***Ice forecasts***

The hydrological forecasting service should determine which river reaches are prone to the formation of ice and ice jams. The expected effects of ice jams on water levels should also be assessed.

3.16 ***Dissemination and communication of forecasts and warnings***

Members should ensure preparation and timely dissemination, to relevant users, of hydrological forecasts and warnings. Such information should be fit for purpose for integration into decision-making processes and procedures related to the protection of life and property and the general welfare of the public.

Note: Dissemination of warnings is one of the key components of an early warning system.

3.17 **Public education and outreach**

Members should engage in education, awareness and preparedness activities aimed at helping citizens and specialist users to make the best use of hydrological forecast and warning information, to understand the potential threats of floods and droughts, and to be aware of the appropriate response actions. Members should strive to make these products accessible to non-specialists and specialists.

Note: Enhancing the response capacity of users through public education and outreach is a key component of end-to-end early warning systems.

3.18 **Forecast evaluation and verification**

The hydrological forecasting service should constantly monitor the quality of its output. Such monitoring should lay emphasis on the value of the forecasts to potential users, and hence the evaluation should be based on their accuracy and timeliness, as well as the responsiveness of the users when forecasts and warnings are issued.

Note: Information on operational forecast verification is given in the [Guide to Hydrological Practices](#) (WMO-No. 168), Volume II, Chapter 7, and in the WMO *Guidelines on Verification of Hydrological Forecasts* (in preparation).

3.19 **International basins**

Members should organize the exchange of hydrological forecasts and warnings for international basins on the basis of bilateral or multilateral agreements. Provision should be made in the agreements for the effective usability of prediction and forecasting products (for example, by including requirements for common datum and common system of units, and by addressing different language and time zone issues) (see note [2.10.5](#)).

CHAPTER 4. WATER QUALITY MONITORING

Water Quality Monitoring

Members should establish water quality monitoring programme(s) as specified in the WMO *Manual on Water Quality Monitoring* (in preparation).

5.3 **Meteorological forecasts and warnings for hydrological purposes**

5.3.1 **Members shall ensure that meteorological forecasts and warnings for hydrological purposes are made available routinely to the hydrological forecaster as required.**

5.3.2 The programme on forecasts and warnings for hydrology should include:

- (a) The type of meteorological information listed in section 5.2. The forecasts should be regular and detailed, specifying to the greatest possible extent local and regional variations;
- (b) The following forecasts:
 - (i) Quantitative precipitation forecasts (QPFs) for periods of up to 120 hours when feasible;
 - (ii) Air temperature, humidity, dew point, wind and sky conditions for up to 5 days;
 - (iii) Wind speed and directions for 24 hours or more;
- (c) Warnings of hazardous weather conditions, preferably with information on uncertainty, particularly in the following cases:
 - (i) Heavy precipitation (amount and intensity);
 - (ii) Sudden and persistent changes in temperature to above or below freezing;
 - (iii) Strong winds.

5.4 **Publication and dissemination of climatological data for hydrological purposes**

5.4.1 Each Member should publish annually its climatological data for hydrological purposes in addition to those published as climatological data.

5.4.2 The publication of climatological data for hydrological purposes should conform with *WMO Guidelines on the Calculation of Climate Normals* (WMO-No. 1203), Chapter 4, and *Guide to Climatological Practices* (WMO-No. 100), Chapter 6.1, except that these data should be grouped according to main drainage basins.

5.4.3 Climatological data published or disseminated for hydrological purposes should include frequencies, sums or averages, as applicable, of the following elements and for the time units indicated in 2.12.4:

- (a) Air temperature;
- (b) Relative humidity;
- (c) Wind speed and direction;
- (d) Precipitation amount and intensity;
- (e) Solar radiation;
- (f) Snow cover;
- (g) Pan evaporation;

- (h) Wet-bulb temperature;
- (i) Sunshine duration.

5.5 **Precipitation data and quantitative precipitation forecasts**

The hydrological forecaster should be supplied with QPFs on a regular basis, and these should be frequently updated during flood situations. The meteorological forecaster making the QPF should have available all current precipitation observations including those made primarily for hydrological purposes.

5.6 **Meteorological observational and forecast data other than precipitation**

Members should make available to the hydrological forecaster the following types of meteorological information, data and forecasts at standard times:

- (a) Temperature, including:
 - (i) Current data;
 - (ii) Forecasts of abrupt and sizeable changes;
 - (iii) Forecasts of unusually high or low temperatures;
 - (b) Wind, including:
 - (i) Current data;
 - (ii) Forecast of unusually high winds;
 - (iii) When hydrologically significant, forecast of abrupt changes in wind direction;
 - (c) Meteorological data related to evapotranspiration computations:
 - (i) Solar radiation or per cent sunshine;
 - (ii) Dewpoint temperature or relative humidity;
 - (iii) Observed pan evaporation.
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For more information, please contact:

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