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ABSTRACT

A working group of the Commission for Hydrometeorology has prepared this report to fill a need for detailed syllabi for instruction in hydrometeorology required by different levels of personnel. This situation has been brought about by the shortage or lack of national cadres of hydrologists in developing countries to undertake comprehensive water management investigations and measures. Hydrometeorologists are classified in three categories: (1) specialists with at least a university degree in engineering or appropriate science, (2) specialists trained to a semi-professional technician level, and (3) specially trained observers, hydrometric assistants. Qualifications required at each level are enumerated, together with recommended curricula and programs for training each of the three classes of personnel. In addition, a number of proposals are suggested regarding the organization of training hydrometeorological experts of various levels for developing countries. The need for concerted action of all international organizations in the training of hydrometeorological staff is also briefly described. Publications of the World Meteorological Organization are listed. (BL)

WORLD METEOROLOGICAL ORGANIZATION

TRAINING OF HYDROMETEOROLOGICAL PERSONNEL

Report of a Working Group of the Commission for Hydrometeorology

WMO-No.219.TP.116

Secretariat of the World Meteorological Organization - Geneva - Switzerland

WORLD METEOROLOGICAL ORGANIZATION

TRAINING OF HYDROMETEOROLOGICAL PERSONNEL

Report of the CHy Working Group on Training in Hydrometeorology
prepared by
Messrs. K. A. Hzmaljan (chairman), E. F. Brater, Z. Mikulski, C. H. Munro and M. Podani

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NOTE

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FOREWORD

Recognizing the need for detailed syllabi for instruction in hydrometeorology, the WMO Commission for Hydrometeorology (CHy), at its second session (Warsaw, 1964), decided to establish a Working Group on Training in Hydrometeorology. This group was requested to prepare detailed syllabi for the three main levels of hydrometeorological staff, i.e., the professional, technical assistant and observer levels.

The working group consisted of Messrs. K.A. Hzmaljan (U.S.S.R.), Chairman, E.F. Brater (U.S.A.), Z. Mikulski (Poland), C.H. Monro (Australia) and M. Podani (Romania). The final report of the working group was submitted to the President of the Commission for Hydrometeorology.

The President of CHy, as authorized by the Commission, approved the report on behalf of the Commission. In view of the importance of its contents, the President also recommended that the report be published as soon as possible in the most appropriate manner. The report has, accordingly, been included in the series of WMO publications intended for training purposes.

I should like to take this opportunity to express to the chairman and to all of the members of the working group the sincere appreciation of the World Meteorological Organization for the time and effort which they have devoted to the preparation of this very valuable report. I am sure that the report will be of great assistance to all concerned with training in hydrometeorology.

D A Davies

(D.A. Davies)
Secretary-General

TRAINING OF HYDROMETEOROLOGICAL PERSONNEL

Prepared by the CHy Working Group on Training in Hydrometeorology,
based on proposals by Dr. K.A. Hzmaljan,
Chairman of the working group

INTRODUCTION

Owing to the increasing demand for water for agricultural, industrial, power, transport and domestic purposes, a large number of countries are obliged to undertake comprehensive water management measures with a view to the reorganization of the water balance of river basins, major river diversions, the creation of reservoirs, the regulation and transfer of run-off from certain basins to others, etc.

The implementation of these water management measures in turn calls for the timely and detailed investigation of water resources and the hydrological regime of rivers and lakes; similarly, all hydrometeorological factors and the possibility of their modification must be explored.

However, the conduct of these investigations in the developing countries is hampered by a shortage or even complete lack of national cadres of hydrologists (hydrometeorologists).*

During the past few years, in connexion with the implementation of the International Hydrological Decade programme under UNESCO auspices, a number of measures have been taken with a view to the training of hydrological experts for the developing countries. WMO naturally also wishes to contribute to the task of assisting in the training of national cadres of hydrometeorologists.

In order to provide training of a sufficiently high order for hydrometeorologists and in order to ensure a certain amount of standardization in training, this note presents recommended curricula and programmes for the training of hydrometeorologists of various levels, as well as a number of proposals on the organization of training in the developing countries.

1. Classification of hydrometeorological personnel

It is recommended that the following classification of hydrometeorologists should be followed :

(a) Class I hydrometeorologists (specialists with at least University degree in engineering or appropriate science);

(b) Class II hydrometeorologists (specialists trained to a semi-professional technician level);

(c) Class III hydrometeorologists (specially trained observers, hydrometric assistants).

*) In referring to these specialists (hydrologists) we shall, for the sake of convenience, use the WMO term "hydrometeorologist", which emphasizes the close relationship between hydrological and meteorological processes.

This proposed classification and subsequent proposals do not refer to questions of the training of hydrometeorologists of the highest level, namely scientific workers, since this training is, as a rule, provided in scientific institutions or in Universities in connexion with post-graduate work sometimes leading to advanced degrees on the basis of individual programmes, with rather narrow specialization in a specific hydrological field.

2. Qualifications required of hydrometeorologists of various levels

(a) Class I hydrometeorological personnel are highly qualified specialists with comprehensive training in one or more aspects of the hydrological discipline. These include hydrological design, the organization and conduct of hydrological investigations, the study of the laws governing hydrological and related meteorological processes, the hydrological and hydrogeological regime of river basins and lakes, hydrological analysis and forecasting, the conduct of hydrological and related meteorological surveys, and the management and control of the operation of station networks for hydrological purposes;

(b) Class II hydrometeorologists are qualified specialists with good training in the conduct of all types of hydrological and meteorological observations and work carried out at hydrological stations as well as field observations, the processing of observation data and their preparation for publication in yearbooks or reference books, the installation, verification and field repair of hydrological instruments and equipment, and the management and control of the operation of hydrological station networks;

(c) Class III hydrometeorologists are persons who, as a result of their training, can conduct hydrological and meteorological observations as well as the initial processing of observation data, including the measurement and calculation of river discharge. The duties of Class III hydrometeorologists also include the proper maintenance and care of the instruments and equipment they use in their work.

3. Preliminary qualifications

The proposals of training programmes for hydrometeorologists of various classes are based on the assumption that persons to receive the training already possess the following general basic education :

(a) Candidates for Class I hydrometeorological training should have attained a level or education required for University entrance or possess the knowledge required of Class II hydrometeorologists;

(b) Candidates for Class II and III hydrometeorological training should possess, prior to training, an equivalent to a partial completion of secondary school (2 or 3 years below the level of training required for University entrance).*

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*) The qualifications for Class III hydrometeorological training may be somewhat lower, depending upon circumstances. In this case, any deficiency in qualifications, such as in mathematics, of candidates for Class III hydrometeorological training should be rectified by additional training in those subjects during the course of the Class III training programme.

4. Time required for completion of recommended programmes

It is realized that, in many countries, the usual method of training of Class I hydrometeorological personnel envisions that the student will first obtain a bachelor's degree in engineering or an appropriate science and will then follow specialized hydrometeorological studies in a post-graduate course. This is a satisfactory method. However, this Technical Note proposes a suggested model course based on the assumption that the student will enter directly into an undergraduate degree course specializing in hydrometeorology. For countries which do not use this method, training in only those subjects which the student has not previously studied need be provided.

For training hydrometeorological personnel to Class I proficiency, approximately three and a half years of study are required. Of this time, approximately 50% will be devoted to theoretical training while the remainder will, in some academic systems, be devoted to laboratory and practical work and, in others, will be accomplished as unsupervised assignments.

Approximately two and a half years are required for the training of candidates for Class II hydrometeorological training with about the same ratio of theoretical training to practical and laboratory work (or home work).

Candidates for Class III hydrometeorological training will require approximately six months to complete the necessary courses of which 40% will be devoted to theoretical training with the remainder devoted to practical exercises and laboratory work (or home work).

The period of instruction indicated is that length of time required for the completion of the curricula given. For candidates undergoing Class I training, an additional period of one year should be allowed for courses in the humanities, in foreign languages and elective specialized subjects. For candidates for Class II training this period of additional time may be shortened to one-half year.

The recommended curricula and programmes for the training of Class I and II hydrometeorologists are in the nature of optimum programmes. They provide for the study of special subjects as well as of a large number of general subjects (mathematics, physics, chemistry, etc.). For this reason, whenever students have a good basic education (for example, incomplete higher education or a higher education in another technical field) the duration of training can be reduced by the elimination from the curriculum of subjects which they have previously studied.

5. Recommended curricula and training programmes for hydrometeorologists of Classes I, II and III

In the compilation of curricula and programmes for Class I hydrometeorologists, account was taken of the fact that hydrology is associated with the natural and engineering sciences, which require a thorough basic education in physics and mathematics. It was also borne in mind that in order to be able to satisfy the requirements of water management organizations and hydraulic engineering enterprises, hydrometeorologists must also have adequate engineering training.

The following recommended curricula for the training of Class I, II and III hydrometeorologists indicate the subjects to be studied and the approximate time (in hours) to be devoted to the theoretical and practical study in each subject; they also indicate the recommended sequence (in years) in which various subjects are to be studied.

Although no specific courses have been included in the curricula it is believed essential that students in Class I attain a high degree of competence in written and oral communications and highly desirable that non-technical courses be elected in such fields as economics, geography, foreign languages, literature, etc. Some students will also wish to continue certain aspects of their education by electing additional technical courses. These may be of a general nature such as strength of materials, electronic, electrical engineering, hydraulic machinery, soil science, agronomy, plant ecology, etc., or of a more specialized hydrological nature such as forest hydrology, watershed management, agricultural hydrology, water resource economics, etc.

The recommended curricula for Class I, II and III hydrometeorologists are given in Annexes 1, 2 and 3.

The advantage of using recommended curricula and programmes is that they ensure a specific, more or less uniform, level of training. However, it is clearly undesirable to aim at excessive standardization of curricula and programmes which would fail to reflect local conditions and might undermine the creative spirit of the instructors. For this reason, the directors of educational institutions, educational centres and courses should be left free to adapt these programmes in the light of the latest scientific achievements and local conditions, to change the number of hours devoted to various subjects and the sequence in which they are taken up, and to introduce optional subjects. Any action taken along these lines must however observe strictly the condition that all students must receive the necessary minimum of theoretical knowledge and adequate practical training.

Particular attention in the training of hydrometeorologists should be paid to practical work (problems and exercises, laboratory work, work with instruments and equipment; study of their design, details and parts, repair and maintenance), as well as to practical work in class and in the field, particularly as regards meteorological and hydrological observations and surveying, which should be carried out at a specially equipped hydrological field training situated near to the place of instruction (class practical work) and under field conditions at operational hydrological stations or at observatories (practical field work).

During the training, efforts should be made to ensure that practical and theoretical work should, as far as possible, be based on the use of local materials, representing the regional physical, geographic and hydrometeorological peculiarities of areas where the student will work.

The knowledge acquired by students is tested and evaluated by means of examinations which are given on completion of the theoretical and practical work on each subject in the curriculum. If the course is a long one, examinations can be given after each completed part. Examinations should be given about twice a year, just before holidays, and students should be allowed 2-3 free days to prepare each subject.

For students who have completed training and passed all examinations in WMO-sponsored courses, the following titles and certificates might be awarded by WMO :

(a) Class I hydrometeorologists - a diploma or degree certifying that they have received university education;

(b) Class II hydrometeorologists - a diploma certifying that they have received a secondary education;

(c) Class III hydrometeorologists - a certificate indicating that they have received training at the hydrological observer-hydrometrist level.

5.1 Recommended curriculum for the training of Class I hydrometeorological personnel

Subjects basic to the study of hydrology

No.	Subject	Duration of course (in hours)
1.	Higher mathematics	500 (for explanation of hours of tuition, see end of paragraph 5.3)
2.	Physics	300
3.	Principles of geometry and descriptive drawing	50
4.	Theoretical mechanics and fluid mechanics	200
5.	General chemistry and hydrochemistry	140
6.	Principles of geophysics, geology, geomorphology and soil science	160
7.	Surveying	180
8.	Hydraulics and open channel flow dynamics and channel processes (river bed formation)	260
9.	General meteorology and climatology	260
10.	Synoptic meteorology	130
11.	General hydrology	200
12.	Streamflow and hydrological calculations	180
13.	Hydrometry	600
14.	Hydrological forecasts	160
15.	General and special hydrogeology	170
16.	Principles of hydraulic engineering, water management and water management calculations	110
	TOTAL	3600

5.2 Recommended curriculum for the training of Class II hydrometeorological personnel

No.	Subject	Duration of course (in hours)
1.	Mathematics	350 (for explanation of hours of tuition, see end of paragraph 5.3
2.	Physics	200
3.	Chemistry	80
4.	Physical geography	110
5.	Principles of drawing	50
6.	Surveying	170
7.	Meteorology	340
8.	Hydrology	300
9.	Hydrometry	600
10.	Elements of hydrological forecasts	100
11.	Elements of hydraulic engineering, water management and water resources analysis	100
	TOTAL	2060

5.3 Recommended curriculum for the training of Class III hydrometeorological personnel

No.	Subject	Duration of course (in hours)
1.	Surveying	100 (for explanation of hours of tuition, see end of paragraph 5.3)
2.	Meteorology	200
3.	Hydrology	150
4.	Hydrometry	270
	TOTAL	720

The number of hours indicated for each course is based on a total class, laboratory and study time. These values can be converted approximately to credit-hours, as used in many universities, by dividing by 30 except for hydrometry which, because of its laboratory content, should have the number of hours divided by 60.

6. Organization of training for hydrometeorological experts of various levels for the developing countries

In view of the increasingly higher level of qualifications required of specialists in general and of hydrometeorologists in particular, and continuing difficulties of organizing training for highly qualified hydrometeorologists in many developing countries, it is desirable that, during the next few years, the training of Class I hydrometeorologists should consist mainly in sending students which have a sufficiently high educational level and possessing a secondary school certificate from the developing countries to educational institutions in the industrially developed countries.

In this connexion it would be desirable to address a recommendation to the competent organizations in the developing countries that they should make greater use of bilateral cultural and scientific and technical co-operation agreements as well as the training facilities, the scholarships and fellowships offered by international organizations (UNESCO, WMO, FAO, WHO, UN and its Economic Commissions, etc.). Students from the developing countries should be given the opportunity of using, in their practical training, materials representative of the hydrometeorological regime of the territory and of the hydraulic works of their respective countries.

In addition to the training provided for hydrometeorologiste from the developing countries in the developed countries, assistance of every kind should be offered in the organization of training for Class I hydrometeorologists in universities having the necessary facilities in the developing countries.

In view of the close relationship between meteorology and hydrometeorology, preference in the selection of universities should be given to those where highly qualified meteorologists are already being trained.

The training of Class II hydrometeorologists can be organized at the national and regional level in existing and newly established WMO regional training centres for the training of meteorologists as well as through the establishment of special regional centres on the basis of bilateral or multilateral agreements between the developing countries.

The training of Class III hydrometeorologists should be provided at the national level by the organization of special courses.

Wherever necessary, the developing countries should receive assistance in the organization of training of hydrometeorologists through the preparation of educational materials and the assignment of qualified teachers. This assistance can also be provided at the international level as well as on the basis of bilateral, cultural and scientific and technical co-operation agreements.

The above proposals concerning the organization of training for hydrometeorologists in essence do not conflict with the recommendations set forth in the documents of the first session of the Co-ordinating Council of the International Hydrological Decade (Paris, 24 May to 3 July 1965, section on "Training of Hydrologists").

7. The need for concerted action of all international organizations in the training of hydrometeorological staff

In view of the fact that problems relating to the training of hydrometeorologists (hydrologists) for the developing countries are being considered by a number of specialized agencies (WMO, UNESCO, FAO, etc.), close and continual co-ordination

of their respective activities must be ensured in order to avoid duplication and dissipation of effort. This co-ordination can be achieved through the joint consideration and solution of the most important theoretical and practical questions relating to the training of hydrometeorologists, the preparation and implementation of agreed plans for helping the developing countries in the training of hydrometeorological staff, systematic exchanges of information, and similar activities. This will not only help to ensure more rational use of the facilities of the specialized agencies in helping the developing countries but will also ensure a more rational solution of problems connected with the methods used for the training of hydrometeorologists.

ANNEX 1

RECOMMENDED PROGRAMMES FOR THE TRAINING OF CLASS I HYDROMETEOROLOGICAL PERSONNEL

1. HIGHER MATHEMATICS

1.1 Analytical geometry

1.1.1 Analytical geometry in plane

1.1.2 Determinants and systems of linear equations

1.1.3 Vectorial algebra

1.1.4 Analytical geometry in space

1.2 Introduction to mathematical analysis

1.2.1 Value and number

1.2.2 Functions

1.2.3 Limits. Continuity

1.3 Differential calculus of functions with one variable

1.3.1 Derivative and differential

1.3.2 Application in function analysis

1.3.3 Application in geometry

1.4 Integral calculus of functions with one variable

1.4.1 Indefinite integral

1.4.2 Definite integral

1.4.3 Use of a definite integral

1.5 Series

1.5.1 Numerical series

1.5.2 Power series

1.5.3 Numerical and power series with complex number terms

1.5.4 Fourier series

1.6 Differential equations

1.6.1 First order equations

1.6.2 Second and higher orders equations

1.6.3 Linear equations of the second and higher orders

1.7 Differential calculus of functions with several variables

1.7.1 Functions with several variables

1.7.2 Derivatives and differentials

1.7.3 Application of several variables
1.7.4 Double and triple integrals
1.7.5 Surface and curvilinear integrals

1.8 Theory of fields
1.8.1 Scalar field
1.8.2 Vector field

1.9 Theory of probability
1.9.1 Direct determination of probability
1.9.2 Various conditions of probabilities
1.9.3 Law of large numbers

1.10 Mathematical statistics
1.10.1 Laws of mathematical statistics
1.10.2 Theory of correlation

1.11 Equations in mathematical physics
1.11.1 Equation of heat conductivity
1.11.2 Laplace equation
1.11.3 Diffusion equation
1.11.4 Wave equation
1.11.5 Elements of operator calculus

1.12 Numerical calculus methods
1.12.1 General rules of approximative calculations
1.12.2 Interpolation and approximative functions
1.12.3 Numerical differentiation and integration
1.12.4 Calculation methods in linear algebra
1.12.5 Method of grids

1.13 Computers and programming
1.13.1 The operation of electronic computers and principles of programming
1.13.2 Methods of automatic programming

2. <u>PHYSICS</u>
2.1 Physical basis of mechanics
2.1.1 Mechanics of the solid phase
2.1.2 Mechanics of liquids and gases

2.2	Molecular physics and thermodynamics
2.2.1	Physical basis of the molecular-kinetic theory
2.2.2	Physical basis of thermodynamics
2.2.3	States of aggregation and phase transitions
2.3	Electricity and magnetism
2.3.1	Electrostatics
2.3.2	Direct current
2.3.3	Electromagnetism
2.4	Oscillations and waves
2.4.1	Mechanics of ascillations and waves
2.4.2	Electromagnetic oscillations and waves
2.5	Optics
2.5.1	Elements of the wave theory of light and geometric optics
2.5.2	Elements of electronic optics
2.5.3	Interference and diffraction of light
2.5.4	Polarization and dispersion of light
2.5.5	Optics of moving bodies and the theory of relativity
2.5.6	Thermal radiation. Photoelectric effect and pressure of light
2.6	Physics of atoms and molecules
2.6.1	Electronic shell of the atom and Bohr's theory
2.6.2	Elements of quantum mechanics
2.6.3	Periodic system of elements and spectra
2.6.4	Molecules and polymers
2.7	Physics of solid bodies
2.7.1	Elements of the lattice theory
2.7.2	Elements of the zone theory of solid bodies
2.8	Physics of the atomic nucleus and elementary particles
2.8.1	Natural radioactivity
2.8.2	Composition of the atomic nucleus
2.8.3	Gamma-rays and neutrons
2.8.4	Nuclear reactions

3. PRINCIPLES OF DESCRIPTIVE GEOMETRY AND TECHNICAL DRAWING

3.1 Principles of descriptive geometry

3.1.1 Point

3.1.2 Straight line

3.1.3 Planes

3.1.4 Methods of conversion of projections

3.1.5 Axonometric projections

3.2 Technical drawing

3.2.1 Technique of constructing geometrical figures

3.2.2 Principles of projection drawing

3.2.3 Principles of topographic drawing

4. THEORETICAL MECHANICS AND FLUID MECHANICS

4.1 Statics

4.1.1 Composition of forces

4.1.2 Parallel forces; theory of couples on a plane surface

4.1.3 Plane system of forces

4.1.4 General system of forces

4.1.5 Centre of parallel forces and centre of gravity

4.2 Kinematics

4.2.1 Kinematics of a point

4.2.2 Translation and rotation motion of a solid body

4.2.3 Complex motion

4.2.4 Plane-parallel motion of a solid body

4.3 Dynamics

4.3.1 Differential equations of the motion of a material point

4.3.2 Dynamics of the relative motion of a material point

4.3.3 Theorems on the amount of motion of a material point and system

4.3.4 Theory of shocks

4.3.5 Theorems on the moment of the amount of motion of a material point and on the kinematic moment of a system

4.3.6 Theorems on the variation in the kinetic energy of a material point and system; general law of energy conservation

4.3.7 d'Alembert's principle and principle of virtual displacements

4.4 Fluid mechanics
4.4.1 Kinematics of a liquid
4.4.2 Hydrostatics
4.4.3 Hydrodynamics of an ideal liquid
4.4.4 Wave theory
4.4.5 Dynamics of a viscous liquid

5. GENERAL CHEMISTRY AND HYDROCHEMISTRY
5.1 General chemistry
5.1.1 Atomic-molecular theory
5.1.2 Structure of the atom and the periodic system of elements
5.1.3 Chemical combination and the structure of molecules
5.1.4 Kinetics and chemical equilibrium
5.1.5 Theory of solutions
5.1.6 Basic principles of electrochemistry
5.1.7 General properties of metals; alloys
5.1.8 First group of the periodic system of elements
5.1.9 Second group
5.1.10 Third group
5.1.11 Fourth group
5.1.12 Organic combination
5.1.13 Fifth group
5.1.14 Sixth group
5.1.15 Seventh group
5.1.16 Eighth group
5.1.17 Zero group

5.2 Hydrochemistry
5.2.1 Water as a solvent; its properties
5.2.2 Electrolyte solutions
5.2.3 Principles of physico-chemical analysis
5.2.4 Surface phenomena and adsorption
5.2.5 Basic problems of colloidal chemistry
5.2.6 Chemical composition of natural water
5.2.7 Chemical composition of atmospheric precipitation
5.2.8 Chemistry of rivers, lakes and reservoirs

5.2.9 Chemistry of ground water

5.2.10 Chemistry of seas and oceans

5.3 Water pollution

6. PRINCIPLES OF GEOPHYSICS, GEOLOGY, GEOMORPHOLOGY AND SOIL SCIENCE

6.1 Principles of geophysics and general information about the globe

6.1.1 Shape, dimensions and types of motion of the globe

6.1.2 Layers surrounding the globe: atmosphere, hydrosphere, biosphere, lithosphere and bathysphere; their composition, structure, thermodynamic conditions and state of aggregation

6.1.3 Terrestrial magnetism, density of the earth and distribution of gravity forces over its surface

6.1.4 Distribution of and relationship of water and land on the earth's surface

6.2 Principles of geology

6.2.1 Composition of the earth's crust, distribution of chemical elements in the earth's crust

6.2.2 Minerals and rocks

6.2.3 Geological processes, tectonics and mountain formation phenomena

6.2.4 Historical geology methods

6.3 Principles of geomorphology

6.3.1 Classification of types of relief: morphological, orographic and genetic

6.3.2 Action of flowing water and erosion. Rivers and climate

6.3.3 Water-accumulation forms of relief

6.3.4 Karst and glacier forms of relief; forms of relief in deserts and mountainous areas

6.4 Principles of soil science

6.4.1 Soil formation, soil as polydispersion system

6.4.2 Physics of soil

6.4.3 Chemistry of soil

6.4.4 Classification of soils

6.4.5 Soil and water

6.4.6 Movement of soil water

6.4.7 Hydrological properties of soils

6.4.8 Soil water balance

7. SURVEYING

7.1 Plan and map

7.2 Principles of theory of errors in measurements

7.3 Measurement of lines in the field

7.4 Optical parts of geodetic instruments

7.5 Theodolite and theodolite survey
7.6 Levelling
7.7 Combined planimetric-altimetric surveys
7.8 Approximation surveys
7.9 Geodetic network
7.10 Geodetic applications in stationary and field hydrological surveys
7.11 Principles of aerial photography
7.12 Principles of cartography

8. HYDRAULICS; OPEN CHANNEL FLOW DYNAMICS AND CHANNEL PROCESSES (RIVER BED FORMATION)

8.1 General hydraulics
8.1.1 Hydrostatics
8.1.2 Principles of hydrodynamics
8.1.3 Flow through small and large orifices at constant and variable pressure
8.1.4 Steady flow in open channel
8.1.5 Pressure flow of a liquid in pipes
8.1.6 Non-steady flow
8.1.7 Spillways and flow over structures
8.1.8 Hydraulic jump and energy discipators

8.2 River hydraulics
8.2.1 Non-uniform flow in channels
8.2.2 Flow with a variable discharge
8.2.3 Unsteady flow in open channels
8.2.4 Hydraulics of bifurcations and estuaries

8.3 Principles of similitude

8.4 Principles of the dynamics of streams with a non-erodable bed
8.4.1 Mechanics and structure of two dimensional channel flow
8.4.2 Hydromechanical analysis of two dimensional turbulent flow
8.4.3 Non-rectilinear flow and additional resistance of channel to flow

8.5 Physical and hydromechanical basis of the theory of flow in an eroding channel
8.5.1 Main mechanical and hydraulic characteristics of river beds and sediments
8.5.2 Mechanism of sediment transport

8.6 Channel processes

8.6.1 Hydrodynamic and hydromorphological approach to the channel processes theory

8.6.2 Basic river bed processes produced by the construction of hydraulic structures

9. GENERAL METEOROLOGY AND CLIMATOLOGY

9.1 General properties of the atmosphere

9.1.1 Composition and structure of the atmosphere

9.1.2 Basic gas laws applicable to the atmosphere

9.1.3 Principles of atmospheric statics

9.2 Radiant energy in the atmosphere

9.2.1 Solar radiation

9.2.2 Effective radiation and radiation balance

9.3 Heat exchange in the soil, water and atmosphere

9.3.1 Heat regime of the soil and bodies of water

9.3.2 Principles of atmospheric thermodynamics

9.3.3 Heat transfer in the atmosphere; air temperature

9.3.4 Vertical distribution of air temperature

9.4 Water cycles in the atmosphere

9.4.1 Evaporation and methods of measurement

9.4.2 Air humidity and methods of measurement

9.4.3 Condensation of water vapour; international cloud classification

9.4.4 Precipitation and methods of measurement, including radar

9.4.5 Snow pack and snow surveys

9.5 Wind measurement methods

9.6 Climatological problems and investigation methods. Relationship with meteorology and hydrology

9.6.1 Climatological data processing methods

9.6.2 Basic factors of climate formation

9.6.3 Influence of relief on climate

9.6.4 Influence of snow and ice cover on climate

9.6.5 Geographical distribution of climatic elements over the globe

9.6.6 Classification of climates

9.6.7 Microclimate and local climate

9.6.8 Changes in climate and climatic fluctuations

9.6.9 Climates of the world

9.7 Network of meteorological stations; observation times and the transmission of information

10. SYNOPTIC METEOROLOGY

10.1 General information on synoptic meteorology and short-range weather forecasts

10.1.1 Basic synoptic codes; prospects of using meteorological satellite data; elements of World Weather Watch

10.1.2 Compilation and analysis of weather charts

10.1.3 Analysis of the fields of meteorological elements

10.1.4 Air masses; their classification and properties

10.1.5 Atmospheric fronts

10.1.6 Cyclone activity

10.1.7 Analysis and short-range forecasts of the synoptic position and weather conditions

10.2 Macrosynoptic processes and long-range weather forecasts

10.2.1 Laws of general atmospheric circulation

10.2.2 Peculiarities of circulation in various areas of the globe and types of macrosynoptic processes

10.2.3 Methods of long-range weather forecasts covering long and short periods

10.3 Quantitative precipitation forecasts

10.4 Radar precipitation measurements

11. GENERAL HYDROLOGY

11.1 Role of water in economic activities

11.1.1 Bodies of water on the globe; general information on oceans, seas, large lakes and rivers

11.1.2 The water cycle on the globe; the general principles of water balance

11.1.3 General information on the structure of water, ice, snow and water vapour

11.2 River systems and basins

11.2.1 Definition of rivers; formation of river system; watershed divides

11.2.2 Definition of a basin; boundary and configuration of basins; measurement of basins

11.2.3 Morphological and physico-geographical characteristics of basins

11.2.4 Characteristics of river systems; classifications of tributaries;

11.3 River valleys and channels

11.3.1 River valleys and their types

11.3.2 River beds and flood plains

11.3.3 Plane formation of river channels; formation of bed cross-section

11.3.4 Types of movement of water in river beds; circulation currents and vortex motion

11.4 Sources of runoff

11.4.1 Runoff from rainball

11.4.2 Runoff from snowfall, glaciers and permanent snow

11.4.3 Runoff from groundwater

11.4.4 Influence of climate, relief, soil, geological and other factors on runoff processes

11.5 Water stage and runoff regime

11.5.1 Typical hydrographs

11.5.2 Phases of the hydrologic year

11.5.3 Regulated regime (natural and artificial)

11.5.4 Floods, their development and laws governing their movement

11.6 General principles of streamflow and water balance

11.6.1 Water balance equation and its analysis

11.6.2 Characteristics of streamflow; discharge, volume, depth of runoff discharge in seconds; litre per km^2 and runoff coefficient

11.6.3 Average annual runoff; longterm average annual runoff; seasonal runoff

11.7 Thermal and winter regimes of rivers

11.7.1 Temperature variations in rivers

11.7.2 River freezing processes and ice formation

11.7.3 Ice break processes

11.8 Sediment transport

11.8.1 Energy of running water; erosive action of rivers

11.8.2 Suspended load and its transport; relationship of suspended load to water stage and discharge

11.8.3 Sediment transport of rivers and factors governing the degree of it.

11.8.4 Bed load, its formation and regime

11.8.5 Deformation of the river channel; channel formation processes and their variation in time and along the length of the river; influence of hydraulic structures on channel formation processes

11.8.6 Chemical sediment; basic elements of chemical regime of rivers

11.9 River estuaries and their hydrological peculiarities

11.10 Hydrology of lakes and reservoirs

11.10.1 Lake formation processes and the inflow-outflow balance of lakes

11.10.2 Temperature variations in lakes; calculations of the heat balance of lakes

11.10.3 Salinity, chemical and gaseous composition of lake water

11.10.4 Waves on lakes and reservoirs; calculations of wave height; erosion banks

11.10.5 Current in lakes and reservoirs

11.10.6 Lake deposits, their classification and morphology

11.10.7 Main characteristics of the hydrological regime of reservoirs

11.11 Biology of lakes and rivers; relation between the biology of lakes and rivers and the chemical composition of waters

11.12 Notions on hydrology of marshes

11.13 Principles of oceanography

12. STREAMFLOW AND HYDROLOGICAL CALCULATIONS

12.1 Runoff process theory

12.2 The use of mathematical statistics and the probability theory in hydrology

12.3 Meteorological conditions governing streamflow

12.3.1 Air temperature as a factor in the transformation of water balance elements

12.3.2 Precipitation, its various types and intensity; calculations of average precipitation in river basins

12.3.3 Evaporation from free water surface and from the surface of a river basin; instruments for measuring evaporation and evaporation calculation methods

12.4 Water and heat balance equations; the use of water and heat balance equations for solving various water management problems

12.5 Mean annual runoff

12.5.1 Determination of annual runoff for subsequent hydrological calculations and its accuracy

12.5.2 Influence of climatic and other physical geographic factors on mean annual runoff

12.5.3 Compilation of maps of mean annual runoff isolines, their accuracy and importance

12.6 Variability of annual runoff

12.6.1 Methods of determining variations in annual runoff on the basis of the relationship with precipitation and variations in types of circulation

12.6.2 Use of frequency distribution curves to determine annual runoff variations

12.6.3 Coefficients of variations of annual runoff series and their dependence on the size of the drainage basin and other physiographic factors; methods of determining coefficient of skewness

12.7 Distribution of flow during the year

12.7.1 Statistical and physical methods of calculating this distribution

12.7.2 Nature and types of river inflow methods of compiling runoff hydrographs

12.7.3 Runoff isoline maps and their use

12.7.4 Mass curves of daily flow

12.7.5 Methods of calculating minimum and maximum discharges; meteorological factors of rain runoff. Methods of calculating the intensity and depth of rainstorms

12.8 Flood flow

12.8.1 Definition of flood, rainfall and snow melting floods, maximum probable flood, design flood, recurrence interval flood

12.8.2 Overland flow of flood, infiltration

12.8.3 Hydrograph analysis, unit by hydrograph concept

12.8.4 Flood estimation in small basins, empirical formulae, synthetic hydrograph

12.8.5 Flood frequency analysis

12.8.6 Minimum flow, depletion curves

12.9 Discharge of suspended and chemical load; methods of calculating this load

12.10 Special aspects of hydrological calculations

12.10.1 Methods of calculating runoff in planning drainage and irrigation

12.10.2 Methods of calculating irrigation requirements on the basis of water and heat balance equations

12.10.3 Flood routing

12.10.4 Calculation of maximum water stage of various frequency

12.10.5 Calculation of evaporation from free water surface and from bare soil

12.10.6 Other hydrological calculations

12.11 Water balance surveys

12.11.1 Organization and methods of multipurpose studies of the water balance of basins of rivers and lakes

12.11.2 Methods of stationary and field surveys of water balance elements

13. HYDROMETRY

13.1 Stage regime studies

13.1.1 Principles of the stage regime of rivers, lakes and reservoirs; gauges and datum systems; types of gauges

13.1.2 Choice of reaches for hydrometric observations

13.1.3 Observation times and their dependence on water level regime; recording of maximum and minimum stage. Measurement of the hydraulic slope

13.1.4 Instruments for stage observations (including stage recorders)

13.1.5 Water temperature observations

13.1.6 Processing of hydrometric observations (stage and temperature)

13.2 Soundings

13.2.1 Organization of soundings; river soundings by cross-sections, longitudinal sections and diagonals; determination of sounding profiles

13.2.2 Sounding instruments: manual, mechanical, hydrostatic and acoustic

13.2.3 Processing of sounding data

13.3 Measurement of stream velocity

13.3.1 General notions on streamflow regime; basic principles of flow; distribution and pulsation of velocities

13.3.2 Point and integration methods of measuring velocity; points on the vertical

13.3.3 Instruments for measuring amount and direction of flow and their classification; gauging station equipment, calibration of hydrometric instruments

13.3.4 Processing of velocity data

13.4 Determination of discharge; classification of discharge measurement methods

13.4.1 Volumetric method

13.4.2 Slope-area method and its various applications

13.4.3 Control cross-sections and conditions of their use

13.4.4 Floats

13 4.5 Weirs and flumes

13.4.6 Dilution method

13.4.7 Use of isotopes

13.4.8 Processing of discharge data by graphical and analytical methods and processing of integration measurements

13.5 Relationship between discharge and stage, and calculations of mean daily discharge

13.5.1 Plotting of a rating curve, evaluation of its accuracy and extrapolation of it

13.5.2 Discontinuous rating curves

13.5.3 Calculation of mean daily discharge and compilation of discharge yearbooks

13.6 Sediment discharge computations

13.6.1 Basic data on the regime and the movement of sediment in rivers

13.6.2 Measurement of suspended sediment; methods and instruments

13.6.3 Measurement of bed load; methods and instruments

13.6.4 Laboratory analysis of samples of transported suspended sediment and bed load and sedimentation

13.6.5 Processing of suspended sediment transport and bed load discharge data

13.7 Other types of observations; their conduct and processing; use of instruments

13.7.1 Thermal regime observations and winter regime observations (snow, ice, ice phenomena)

13.7.2 Water transparency and colour observations

13.7.3 Observations of chemical quality of water

13.7.4 Wave observations

13.8 Special work

13.8.1 Determination of the discharge of small rivers using hydraulic structures

13.8.2 Measuring of discharge at hydraulic structures and hydro power plants

13.9 Technical instructions for hydrological stations and their inspection

13.10 Method of hydrometric measurements in laboratory; principles of the similarity theory and modelling methods

13.11 Hydrologic field investigations

13.11.1 Relationship between investigations, planning and construction; stages of an investigation

13.11.2 Characteristic features of investigations used as a basis for the planning and construction of hydraulic engineering works (hydro power plants)

13.11.3 Characteristic features of investigations for navigation and timber floating

13.11.4 Characteristic features of investigations for planning and construction of irrigation systems

13.11.5 Characteristic features of investigations for designing and constructing roads and bridges

13.12 Basic safety techniques and labour protection rules to be observed in carrying out hydrological observations on rivers and lakes

14. HYDROLOGICAL FORECASTS

14.1 General information on hydrological forecasts

14.1.1 Organization of a hydrological information network and a hydrological forecast service

14.1.2 Types of hydrological and meteorological information; codes for transmission of hydrological and meteorological information and forecasts

14.1.3 Collection of scientific and operational hydrological and meteorological data necessary for the computation of hydrological forecasts

14.1.4 Evaluation of forecast errors; reliability of specific methods and natural reliability

14.2 Short-term flow forecasts (stage and discharge)

14.2.1 Classification of short-range hydrological forecasts and forecasting methods

14.2.2 Physico-empirical relationships

14.2.3 Correlation relationships

14.2.4 Isochrone method

14.2.5 Rainfall - loss rate - unit hydrograph method

14.2.6 Stage forecasting

14.3 Long-term flow forecasts

14.3.1 Classification of long-term runoff forecasts and forecasting methods

14.3.2 Methods of corresponding volumes (by volume of water in channel system)

14.3.3 Water balance method

14.3.4 Methods of analogy and methods of standard forecasts

14.4 Forecasting of temperatures

14.5 Short-term and long-term forecasts of ice phenomena

14.6 Use of computers and models in hydrological forecasts

15. GENERAL AND SPECIAL HYDROGEOLOGY

15.1 General hydrogeology

15.1.1 Unity of the natural waters in the world; role of ground water

15.1.2 Classification of rocks and their physical properties

15.1.3 Forms of the physical state and movement of groundwater

15.1.4 Physical properties, chemical composition and radioactivity of groundwater

15.1.5 Origin and classification of groundwater

15.1.6 Water of the aeration zone and water in the soil

15.1.7 Non-artesian (ground) and artesian water

15.1.8 Groundwater in fissured rocks

15.1.9 Mineral waters

15.2 Dynamics of groundwater

15.2.1 Laws of groundwater dynamics

15.2.2 Determination of percolation coefficient and yield for various types of wells

15.2.3 Methods of determining velocity and direction of groundwater flow

15.3 Hydrogeological investigation

15.3.1 Networks of hydrological observation wells

15.3.2 Hydrogeological calculations for water management

15.4 Elementary principles of hydraulic machinery

16. PRINCIPLES OF HYDRAULICS ENGINEERING, WATER MANAGEMENT AND WATER MANAGEMENT CALCULATIONS

16.1 Principles of hydraulic engineering

16.1.1 Construction operations and materials used in hydraulic engineering

16.1.2 Basic hydraulic engineering structure

16.2 Water resources utilisation and control

16.2.1 Hydropower development

16.2.2 Inland waterways

16.2.3 Transport of timber by water (floating)

16.2.4 Irrigation

16.2.5 Drainage

16.2.6 Water supplies to population and industry

16.2.7 Hydraulic engineering in the fishery industry

16.2.8 Soil erosion control

16.2.9 Hydraulic engineering, bridges

16.3 Water resources management

16.3.1 Water resources, their evaluation and economic importance

16.3.2 Water requirements of various sectors of the economy and flow regulation regime

16.3.3 Average per capita consumption for urban water supply and variations in domestic and industrial consumption

16.4 Water management calculations

16.4.1 Water resources management installations and reservoirs

16.4.2 Basic data in water resources management planning

16.4.3 Basic principles of flow regulation theory; calculations using mass diagrams and demand lines

16.4.4 Flow regulation calculations using stochastic methods

16.4.5 Regulation calculations using storage behavior diagrams for developing release role graphs

16.4.6 Other applications of statistical methods to water resource problems

16.4.7 Hydraulic power calculations

16.4.8 Flood control and flood damage mitigation methods

16.4.9 Reservoirs in series and compensation regulation and methods of calculation

ANNEX 2

RECOMMENDED PROGRAMMES FOR THE TRAINING OF CLASS II HYDROMETEOROLOGICAL PERSONNEL

1. MATHEMATICS

1.1 Algebra and elementary functions

1.1.1 The use of approximations and of the slide rule

1.1.2 Equations and inequalities of the first power

1.1.3 Real numbers

1.1.4 Power with rational exponent

1.1.5 Quadratic and biquadratic equations

1.1.6 Vectors

1.1.7 Trigonometric functions

1.1.8 Addition theorems

1.1.9 Series

1.1.10 Exponential and logarithmic functions

1.1.11 Combinations; Newton's binomial

1.1.12 Functions and limits

1.1.13 Derivatives and their application

1.2 Geometry

1.2.1 Metric relationships in the right-angled triangle

1.2.2 Solution of triangles

1.2.3 Straight lines and plane surfaces in space

1.2.4 Polyhedrons and round bodies

1.2.5 Surface of polyhedrons and round bodies

1.2.6 Calculation of the volume of polyhedrons and round bodies

1.2.7 Solution of geometrical problems using trigonometry

1.3 Elements of statistics and probability

2. PHYSICS

2.1 Mechanics

2.1.1 Principles of the kinematics of rectilinear motion

2.1.2 Principles of the dynamics of rectilinear motion

2.1.3 Composition and resolution of forces

2.1.4 Work and energy

2.1.5 Rotational motion

2.1.6 Gravity

2.1.7 Mechanical oscillations and waves

2.2 Molecular physics and heat

2.2.1 Principles of the molecular-kinetic theory and molecular phenomena in gases, liquids and solids

2.2.2 Thermal expansion of bodies

2.2.3 Properties of gases

2.2.4 Heat and work; heat exchange

2.2.5 Changes in the state of aggregation

2.3 Electricity

2.3.1 The electric field

2.3.2 Electric current in metals

2.3.3 Laws of direct current

2.3.4 Electromagnetism

2.3.5 Electromagnetic induction

2.3.6 Electric current in electrolytes

2.3.7 Electric current in gases and in a vacuum

2.3.8 Electromagnetic oscillations and waves

2.4 Optics

2.4.1 Nature of light and its propagation

2.4.2 Geometrical optics

2.4.3 Wave properties of light

2.4.4 Dispersion of light

2.4.5 Quantum properties of light

2.5 Atomic energy

2.5.1 Structure of the atom

2.5.2 Energy of the atomic nucleus and its use for peaceful purposes

3. CHEMISTRY AND HYDROCHEMISTRY

3.1 Chemistry

3.1.1 Basic principles and laws of chemistry

3.1.2 Halogens

3.1.3 Alkali metals

3.1.4 Periodic law and periodic system of elements; nature of matter

3.1.5 Water and solutions; electrolytic dissociation

3.1.6 Oxygen, sulphur and its compounds

3.1.7 Nitrogen, phosphorus and their compounds; mineral fertilizers

3.1.8 Carbon, silicium and their compounds

3.1.9 Metals

3.1.10 Organic matters

3.1.11 Alcohols, phenols and aldehydes

3.1.12 Carbonic acids, esters and fats

3.1.13 Carbohydrates

3.1.14 Synthetic macromolecular substances (polymers)

3.2 Chemistry of water

3.2.1 Chemical composition of natural water and of atmospheric precipitation

3.2.2 Methods for physical and chemical analysis of water

4. PHYSICAL GEOGRAPHY

4.1 General characteristics of the Earth as a planet

4.1.1 Shape and size of the Earth, laws of its motion

4.1.2 Heat regime of the earth's surface; seasons of the year; climatic zones and factors governing them

4.1.3 The position of the Earth in the cosmos

4.1.4 Hypotheses concerning the origin of the Earth

4.1.5 Geographic co-ordinates; types of maps

4.2 Mantles and internal structure of the Earth

4.2.1 Outer concentric mantles of the Earth; atmosphere, hydrosphere and lithosphere; their chemical composition and state of aggregation

4.2.2 Structure of the Earth

4.2.3 Mountain formation processes; earthquakes and volcanic activity

4.2.4 Physical, chemical and organic weathering

4.2.5 Erosive and accumulative action of the wind

4.2.6 Erosive and accumulative action of rivers

4.2.7 The land surface as a result of the interaction of external and internal forces

4.2.8 Relief and its forms; representation of relief on maps

4.3 Hydrosphere

4.3.1 Oceans and seas

4.3.2 Inland waters; rivers and river basins; river valleys

4.3.3 Lakes and their regime

4.4 Introduction of soil science

5. PRINCIPLES OF TECHNICAL DRAWING

5.1 Geometrical drawing

5.1.1 Drawing instruments and equipment; forms of drawings

5.1.2 Inscriptions used in drawing

5.1.3 Geometrical constructions

5.1.4 Scales of drawings

5.1.5 Graphs and collation maps

5.2 Projection geometry

5.2.1 General information on projections; projection methods

5.2.2 Projection of a point and straight line

5.2.3 Projection of plane figures

5.2.4 Projection of geometrical bodies and objects

5.2.5 Section of geometrical bodies by a plane surface

5.2.6 Mutual intersection of the surfaces of geometrical bodies

5.3 Axonometric projections

5.3.1 Principles of axonometric projections and their classification

5.3.2 Construction of axonometric projections

5.4 Principles of topographic drawing

5.4.1 Principles of topographic maps and plans

5.4.2 Agreed symbols in topographic drawings; relief and cross-sections; conventional signs in topographical plans

5.4.3 Peculiarities of drawings of hydrological structures

6. SURVEYING

6.1 General information

6.1.1 Plans and maps

6.1.2 Orientation of plans and maps; measurement of azimuths and rhumbs

6.1.3 Simple surveying measurements; measurement of lines and vertical angles

6.2 Angular-theodolyte surveys

6.2.1 Instruments and the conduct of surveys

6.2.2 Processing of angular survey data

6.3 Geometrical levelling

6.3.1 Instruments and the conduct of levelling

6.3.2 Processing of levelling data

6.3.3 Graphic representation of local relief

6.4 Plane-table topographic survey

6.4.1 Plane-table and alhydade

6.4.2 Conduct of plane-table surveys

6.4.3 Processing of plane-table survey data

6.5 Tacheometric survey

6.5.1 Instruments for and conduct of survey

6.5.2 Processing of tacheometric survey data

6.6 Barometric levelling and approximation surveys

6.6.1 Barometric levelling

6.6.2 Approximation surveys

6.7 Surveying work in hydrological stations

6.7.1 Levelling of the longitudinal section of a water surface

6.7.2 Levelling of the cross-section of a river valley

6.7.3 Altitude relation of the station datum level to the levelling network; levelling of gauging instruments

6.7.4 Semi-instrumental and instrumental survey of reaches at hydrological stations

6.8 Elementary principles of aerial photogrammetry

7. METEOROLOGY

7.1 Meteorology

7.1.1 Basic subdivisions of meteorology, its relationship with hydrology and other sciences

7.1.2 Meteorological elements

7.1.3 Basic principles of meteorological observations

7.2 Measurement of time

7.2.1 Principles of sidereal, mean solar and zone time

7.2.2 Observation times for meteorological elements

7.3 Composition and structure of the atmosphere

7.3.1 Composition of atmospheric air

7.3.2 Structure of the atmosphere in altitude

7.3.3 Horizontal heterogeneity of the atmosphere

7.4 Solar, terrestrial and atmospheric radiation

7.4.1 The sun as a source of energy; basic laws on radiation energy

7.4.2 Direct, diffuse and accumulated radiation; reflected solar radiation, the albedo of various surfaces

7.4.3 Terrestrial radiation; atmospheric counter radiation

7.4.4 Effective radiation; radiation balance of the underlying surface

7.4.5 Actinometric instruments; the conduct of actinometric observations and processing

7.5 Soil temperature

7.5.1 Soil heating and cooling processes, its thermal properties

7.5.2 Diurnal and annual fluctuations in soil temperature at the surface and at various depths

7.5.3 Thermometers for measuring soil temperature; observations and processing

7.6 Air temperature

7.6.1 Air heating and cooling processes

7.6.2	Diurnal and annual variations in air temperature; temperature variations with altitude
7.6.3	Isotherms
7.6.4	Types of thermometers; psychrometer screen; observations and processing
7.7.	Water vapour in the atmosphere
7.7.1	Penetration of water vapour into the atmosphere
7.7.2	Evaporation and its physical substance
7.7.3	Air moisture (absolute and relative)
7.7.4	Diurnal and annual air moisture and evaporation trends
7.7.5	Methods of measuring air moisture and evaporation from soil and water
7.8	Condensation of water vapour in the atmosphere
7.8.1	Conditions of water vapour condensation
7.8.2	Conditions of mist, dew and hoar frost formation
7.8.3	Cloud formation conditions and classification of clouds
7.8.4	Cloud height measurement methods
7.9	Precipitation and snow cover
7.9.1	Types and forms of atmospheric precipitation
7.9.2	Diurnal and annual precipitation trends
7.9.3	Rain and snow formation
7.9.4	Rainfall intensity, hyetographs and isohyetal maps
7.9.5	Precipitation measurement instruments; observations and processing
7.10	Atmospheric pressure and air density
7.10.1	Air weight and pressure; units of measurement
7.10.2	Methods and instruments for measuring pressure
7.10.3	Air density; variations in pressure with height; vertical and horizontal pressure gradient; isobars
7.10.4	Reduction of pressure to sea level; observations and processing
7.11	Air current in the atmosphere
7.11.1	Wind, its direction and speed
7.11.2	Reasons for appearance of wind
7.11.3	Wind systems in cyclones and anticyclones; local winds
7.11.4	Instruments for measuring wind speed and direction; observations and processing

7.12 Optical and electrical phenomena in the atmosphere

7.12.1 Various optical phenomena in the atmosphere and their causes

7.12.2 Meteorological optical range, visibility observations (instrumental and visual)

7.12.3 Various electrical phenomena in the atmosphere and their causes; observations of these phenomena

8. HYDROLOGY

8.1 Physical properties of water and the water cycle on the globe

8.1.1 Physical properties of water

8.1.2 The Hydrological cycle on the earth

8.2 Ground water

8.2.1 Origin and classification of ground water

8.2.2 Physical properties of rocks in relationship to water

8.2.3 Physical states and movement of ground water

8.2.4 Ground water and its relationship to rivers

8.2.5 Confined aquifer ground water and its role in the river feeding

8.3 Lakes and reservoirs

8.3.1 Morphology of lakes

8.3.2 Sources of inflow to lakes; water balance of lakes

8.3.3 Dynamic phenomena on lakes (waves and currents)

8.3.4 Heat regime of lakes

8.3.5 Chemical composition of lake water, biological processes in lakes

8.3.6 Reservoirs, their regime and water balance

8.4 Swamps

8.4.1 Formation and classification of swamps

8.4.2 Hydrological regime of swamps

8.5 Formation and movement of glaciers, their influence on river inflow and regime

8.6 Rivers

8.6.1 River systems

8.6.2 River basins

8.6.3 River valleys and channels

8.6.4 Sources of river flow

8.6.5 Temperature regime of rivers

8.6.6 Regime of river stages

8.6.7 Movement of water in rivers; flow velocity

8.6.8 Discharge in rivers, hydrograph analysis

8.6.9 Sediment transport

8.6.10 Chemical composition of river water

8.6.11 Channel formation processes

8.7 Water balance and runoff

8.7.1 Units used to measure runoff and flow

8.7.2 Water balance of bodies of water

8.7.3 Calculation of evaporation from the surface of a basin

8.7.4 Calculation of evaporation from the surface of a basin

8.7.5 Average long-term annual runoff

8.7.6 Distribution of annual runoff in months and seasons

8.7.7 Flow duration curves, mass diagrams and storage behavior diagrams

8.7.8 Maximum discharge and its calculation

8.7.9 Minimum flow and its calculation

8.7.10 Sediment discharge and its calculation

9. HYDROMETRY

9.1 Water stage and water temperature observations

9.1.1 Choice of area for a gauging station and its establishment

9.1.2 Observations of water stage and water temperature

9.1.3 Processing of observation data

9.2 Soundings

9.2.1 Instruments used for soundings

9.2.2 Sounding methods

9.2.3 Processing of sounding data

9.3 Measurement of flow velocity

9.3.1 General notions; velocity at a point, pulsation; instantaneous and average velocity; distribution of velocity in verticals, across and in the plane of the cross-section of the river

9.3.2 Instruments for measuring velocity and direction of flow

9.3.3 Calibration of current meters

9.3.4 Measurement of flow velocity using by current meters; calculation of velocity

9.4 Measurement of discharge

9.4.1 General notions on discharge; methods of measuring discharge

9.4.2 Choice of emplacement of the gauging station and its equipment

9.4.3 Measurement of discharge by current meter

9.4.4 Measurement of discharge using floats

9.4.5 Methods of measuring discharge on small rivers

9.4.6 Calculation of flow at hydro power stations

9.5 Measurement of suspended sediment and bed load discharge

9.5.1 Measurement of suspended sediment calculation of suspended sediment discharge

9.5.2 Measurement of bed load; calculation of suspended and bed load discharges

9.5.3 Processing of suspended sediment and bed load samples

9.6 Observations of ice phenomena, and of physical properties and chemical composition of water

9.6.1 Observations of ice conditions

9.6.2 Determination of the physical properties of water

9.6.3 Determination of the chemical composition of water

9.7 Estimation of discharge and sediment transport

9.7.1 Plotting of rating curve and calculation of discharge

9.7.2 Extrapolation of rating curve

9.7.3 Calculation of discharge in unstable channel

9.7.4 Calculation of discharge with a variable back water and in channels with vegetation

9.7.5 Calculation of discharge at hydro power stations

9.8 Hydrological observations on reservoirs and lakes

9.8.1 Observations of stage and water temperature

9.8.2 Observations of transparency, colour and chemical composition of water

9.8.3 Observations of wind waves, currents and ice phenomena

9.8.4 Observations of resistance of reservoir banks

9.9 Hydrological observations in swamps

9.10 Technical instructions for hydrological stations and their inspection

9.11 Organization of field hydrological surveys and technical investigations

9.12 Basic safety techniques and labour protection rules to be observed in carrying out hydrological surveys on rivers and lakes

10. BASIC PRINCIPLES OF HYDROLOGICAL FORECASTS

10.1 Collection of hydrological and meteorological data for hydrological informations and forecasts

10.1.1 Codes for transmission of hydrological and meteorological informations and forecasts

10.1.2 Processing of hydrological and meteorological data required for hydrological forecasts

10.2 Basic principles for developing and evaluating the reliability of hydrological forecast methods

10.2.1 Physical elements of hydrological forecasts; physico-empirical relationships; correlation relationships

10.2.2 General principles for the evaluation of forecast methods and reliability; permissible error

10.3 River regime forecasts

10.3.1 Forecasts of stage and discharge on river reaches without tributaries

10.3.2 Forecasts of stage and discharge on river reaches with tributaries

10.3.3 Forecasts of stage and discharge on the basis of corresponding discharge and amount of water in river channels

10.3.4 General principles on rainfall flood forecasts

10.3.5 General principles of mountain river flow forecasts and ice forecasts

11. ELEMENTS OF HYDRAULIC ENGINEERING, WATER RESOURCES MANAGEMENT AND CALCULATIONS

11.1 Main types of hydraulic engineering structures

11.2 The use of water power

11.3 Water transport and timber floating

11.4 Irrigation and drainage

11.5 Water supply and sewerage systems; water pollution

11.6 Purification and filtering of waste waters

11.7 Notions on and elements of water management calculations

ANNEX 3

RECOMMENDED PROGRAMMES FOR THE TRAINING OF CLASS III HYDROMETEOROLOGICAL PERSONNEL

1. SURVEYING

1.1 General information

1.1.1 Plans and maps; scale; types of relief and its representation on plans and maps; cross sections and longitudinal sections

1.1.2 Indication of ground points and bench marks

1.1.3 Measurement of lines; methods of determining ground distances; simplest instruments

1.2 Horizontal and vertical surveys

1.2.1 Principles of measuring horizontal units; instruments used

1.2.2 Principles of levelling; simple levelling and the instruments used

1.2.3 Levelling of a gauge; processing of gauge data

2. METEOROLOGY

2.1 The physical basis of meteorology and its importance

2.2 The atmosphere, its composition and structure

2.3 Basic theory of meteorological observation methods and recording of data; time and its measurement

2.4 The sun as a source of energy; principles of direct, diffuse and accumulated radiation

2.5 Soil temperature; methods of measurement and instruments; processing

2.6 Air temperature; measurement methods and instruments; processing

2.7 Water vapour in the atmosphere; absolute and relative humidity, saturation deficit; measurement methods and instruments; processing

2.8 Condensation of water vapour in the atmosphere; causes of formation of fog and clouds. Main forms of clouds

2.9 Formation and types of clouds; measurement methods and instruments; processing

2.10 Atmospheric pressure and principles of air pressure measurement methods

2.11 Causes of wind; methods of measuring wind speed and its direction; instruments and observation methods

2.12 Opticals and electrical phenomena in the atmosphere and their causes

2.13 Causes for transmission of meteorological information

3. HYDROLOGY

3.1 Physical properties of water

3.2 The hydrologic cycle

3.3 Hydrographic networks

3.3.1 River basins

3.3.2 River valleys and channels

3.4 Ground water

3.4.1 Origin of ground water and its classification

3.4.2 Relationship between surface and ground water

3.5 Lakes and reservoirs

3.5.1 Origin and classification of lakes

3.5.2 Basic morphological and hydrological characteristics of lakes and reservoirs

3.6 Marshes, their origin and hydrological regime

3.7 Formation and types of glaciers; their influence on river feeding

3.8 Stream flows

3.8.1 Sources of streamflow

3.8.2 Thermal regime of rivers

3.8.3 Stage regime of rivers

3.8.4 Stream velocity in rivers

3.8.5 Discharge in rivers

3.8.6 Sediments (suspended and bed load)

3.8.7 Chemical composition of water

3.9 Elements of the water balance

4. HYDROMETRY

4.1 Water stage observations

4.1.1 Types of gauging instruments and their maintenance

4.1.2 Datum level; reductions

4.1.3 The conduct and times of observations at gauging stations

4.1.4 Initial processing of observation materials, compilation of tables and graphs

4.2 Observations of water temperature and ice phenomena on rivers

4.3 Soundings

4.3.1 Simple instruments used in sounding and sounding methods

4.3.2 Processing of sounding data; compilation of cross-section profile

4.4 Measurement of stream velocity; instruments

4.4.1 Basic information on stream velocity and its distribution

4.4.2 Methods of measuring stream velocity; types and design of instruments used for measuring of stream velocity and its direction; maintenance of instruments

4.4.3 Equipment of hydrometric station and its maintenance

4.5 Discharge measurement

4.5.1 Discharge measurement methods

4.5.2 Methods of processing discharge data

4.5.3 Rating curves

4.5.4 Calculation of mean daily discharge

4.5.5 The theory of runoff

4.6 Suspended sediment and bed load discharge measurements

4.6.1 Measurement of suspended sediment types of instruments

4.6.2 Methods of measuring bed load; types and design of instruments

4.6.3 Initial processing of suspended sediment and bed load discharge measurements

4.7 Observations of the chemical composition of water; collection and storage of water samples; first day chemical analysis

4.8 Basic safety techniques and labour protection rules to be observed in carrying out hydrological observations on lakes and rivers

4.9 Information activities of the hydrological stations; codes for the transmission of hydrological information; records

4.10 Maintenance of instruments; installation in stations

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