Hydrological Reports and Forecasts: Introduction

Source: Godrologicheskiye Informatsii i Prognozy, 1945, Russian bk, pp 3-16

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[Title Page of Book:]

HYDROLOGICAL DATA AND FORECASTS

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Moscow 1945 Sverdlovsk

INTRODUCTORY NOTES [pages 3 to 16 of Book]

§ 1. THE IMPORTANCE OF HYDROLOGICAL DATA AND FORECASTING TO THE NATIONAL ECONOMY AND THE DEFENSE OF THE COUNTRY [pp 3-8]

The life of mankind is closely related to water. Since the dawn of history, man grasped the importance of water and its indispensability to life itself, deified it, worshiped it, and wove it into many of his legends. Water is the cotraveler of every culture. Its presence was instrumental in the creation and the growth of cities; its absence resulted in deserts. It has always been instrumental in the propagation of life, and it continues to play this part to our very day.

In his urge to dominate nature, man, gradually discarding his religious prejudices, embarked upon a struggle with the destructive forces of water, for the subjugation of its riches and power to his own use, and continuously, from year to year, in the course of centuries, he penetrated its mysteries and registered wondrous victories over it.

Water is not always benevolent to man. In the course of time it occurs that flooded rivers strike at the peaceful flow of the economic life of the people, inundate cities, villages, crops, and wipe out great values, carrying death and destruction in their wake.

Water is one of the mighty elements of nature, and in or-der to utilize its potentialities in the most rational manner in keeping with our objectives, it is not only necessary to know the past and present characteristics of its cycle, but also to be able to foresee the future characteristics. This forecasting ability allows the necessary time to take measures providing for the rational utilization of waters, as well as for countermeasures against the oncoming disasters.

Hydrological forecasts of the cycles of rivers and seas, and hydrological data in general, are required by the most varied branches of the national economy and the defense of the country, assuming a paramount, frequently decisive, importance in time of war.

Hydrological forecasts are particularly important with relation to the problem of floods, which constitute a national calamity. Figure 1 is a cut showing the flooded city of Omsk on the Irttysh River. The flood occurred on 4 May 1928, when, due to obstructions, the water level attained the unusual height of 798 centimeters, piling up damages into the millions and causing a great loss of lives. The highest flood on record until then occurred in 1892, with the flood level at 652 centimeters.

Figure 1. The flooded city of Omsk, 4 May 1928

A disaster of exceptional dimensions occurred at Alma-Ata in 1921, when on 8 June a heavy rain brought on tremendously destructive flood waters, which bore down upon the city, carrying off houses and human beings in their wake.

In 1931, the swollen waters of the Dnepr River caused tremendous destruction. A number of villages and some cities were inundated; many important industrial plants were threatened; telegraph lines were partially destroyed and communications disrupted; and only because of exceptionally strong countermeasures, the losses, in a number of cases, were kept to a minimum.

Of great interest to the hydrological forecasting service are the limits of the rather frequently recurring floods in Leningrad, particularly the disastrous flood of 23 September 1924 (see "News of the Central Hydrometeorological Bureau TsUMOR, No 1925).

An unprecedented flood occurred in January 1937 in the United States of America, when the Ohio and Mississippi rivers went on a rampage (Ch. F. Brooks and A. G. Tyssen, "The meteorology of the great floods in the eastern part of the United States," the Geographical Review, XXVII, 1937). The flood lasted about two weeks (beginning with January 22) and was the greatest in the history of the United States. American newspapers devoted much space to the description of the details of this disaster, which embraced a large part of the territory of the United States. The underlying causes of this flood are considered to be an unusually severe winter with great accumulations of snow. The sudden thaws and ample rains brought about the unprecedented overflow of the

Ohio and Mississippi rivers.

A number of cities were inundated. Some smaller settlements were completely wiped out, with a loss of several hundreds of lives. (Scottish Geographical Magazine, 1937, March). Powerful currents of dirty, silt-carrying water wrought tremendous destruction in their path, washing out railroad trains, disrupting telegraph and telephone communication lines, and depriving entire areas of electric light. In Cincinnati, Ohio, a city of half a million, the streets were transformed into swirling rivers, with trolley car, bus, and automotive traffic completely at a standstill, with factories and plants idle. Three gasoline storage tanks in the northern part of the city blew up under the tremendous pressure of the swirling waters, with the resulting fires spreading to a considerable part of the city.

The areas affected by the flood were struck by epidemics: tens of thousands suffered with the grippe, pneumonia, etc.

Numerous buildings were destroyed by the currents, and over a million people found themselves without shelter. Over a hundred drownings were recorded and many more perished from epidemic diseases.

The flood of 1937 was of such tremendous force that all the protective structures, erected after the famous flood of 1927, turned out to be totally ineffective. However, due to the forced draught mobilization of a huge amount of technical facilities, some cities in the path of the flood were saved. Thus, the city of

Cairo, located at the confluence of the Ohio and Mississippi rivers, was held. Cairo was guarded against the river by an embankment 18.3 meters high to begin with. Yet, it took the forced draught construction of an additional 0.9 to 1.2 meter embankment superstructure to save the city from the flood.

The basic underlying cause of these disasters in the United States is considered to be the arbitrary manner in which the forest and water resources are controlled. The predatory destruction of the forests, embracing huge areas, constitutes the principal reason for the recurrence of droughts and floods, disasters from which the United States of America have been suffering so extensively during the recent decades.

In France, too, rivers such as the Rhone, Garonne, and the Loire, bring at flood stage considerable suffering to the population of the surrounding areas.

The cut shown in Figure 2 shows the inundation in the western part of India, along the railroad line at the city of Barod. The photograph clearly indicates the extent of the disaster.

Figure 2. Flooded railroad tracks in the city of Barod.

A task of great responsibility and honor evolves upon the forecasting hydrologist, i.e., to warn the population in time about the impending disasters, thereby affording the opportunity for adequate preparation and counter-measures.

Thus, the forecast of the Volga River flood in 1926 made possible timely preparations in a number of places and saved property running into the millions, which otherwise would have been destroyed.

In the cases where great floods are known to occur, special flood-combatting commissions, in close liaison with the hydrological forecasting service, are set up for the purpose of initiating on time the proper countermeasures.

Thus, in 1931, the Kura and the Araks rivers loosed a flood unprecedented by its force and duration. The countermeasures undertaken found their reflection in a decision by the Council of People's Commissars AzSSR dated 23 July 1931. This decision takes note of the fact that, due to the timely countermeasures, only 2,000 hectares were inundated as against an area of 22,000 hectares in the flood of 1920.

Item 3 of the above decision is quoted herewith: "The class-consciousness of the kolkhoz and the poor-and-middle peasant masses, their understanding of the politico-economical problems posed by the Party and the Government on behalf of the toiling peasant masses in the business of the socialist reconstruction of agriculture, resulted in the organization of these masses and in their heroic struggle against the flood of 1931.

"Entire districts, individual kolkhozes, villages, kolkhoz members, and individual owners, under the skilled leadership of local party and Soviet organs, without in any manner detracting from their efforts in the current spring sowing campaign, conducted a heroic struggle against the flood.

"A considerable number of kolkhoz members and individual owners from the Agdash area labored several days on end without rest, very often in chest-deep water, in their valiant attempt to rescue the Soviet cotton crop from the swirling waters of the Kura.

"The timely assistance of the area, rural, Party, and Soviet organizations, the selfless devotion of the engineering and technical personnel, also the personnel of the political organs and the militia of the AzSSR -- all these accounted for the positive results attained in the unusually severe flood of 1931.

"The timely investigation of the entire course of the Kura River segregated the spots of the greatest potential danger, where the necessary material and inventory stocks were concentrated, a 24-hour continuous patrol established, a technical and human line of communication established along the entire rock-crumbling front, etc.

"It was due primarily to the efforts and organizational activities of the supervisory administrative and political personnel that the cotton crop and the peasant labor invested were saved from disaster."

The heroic struggle with the June 1936 flood in Central Asia is described in the "Pravda of the East" issue of 3 June 1936:

"In the morning of May 31, the riverbed of the Kara-Dar'ya at Kampyr-Ravat was suddenly shifted to the right of the bridge, over which the narrow-guage railroad ran across the Khanabad stream.

"After three hours of pounding by the swollen stream, the pier showed signs of buckling, and at 1400 hours it was washed away. Toward the evening the fourth and sixth piers of the bridge were washed away. The bridge spans, deprived of their supports, were hanging precariously over the swirling river. At great risk, workers, crawling along the shaky spans, finally succeeded in throwing across some metal cables for the temporary support of the spans."

"In the Fergansk area the water forced its way through the right bank of the Bishka reservoir, flowing along a mountain slope. After two days of incessant toil, the breakthrough was plugged."

"The work of protecting the 26-kilometer run of the Kuvasay branch railroad proceeds continuously without a letup."

"The situation at the Tentyaksay Dam is still very tense. The floodwaters have undermined the entire structure of the dam,

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as a result of which the continuous protective measures undertaken are, to a great extent, useless. The toiling workers can hardly keep up with the fury of the floodwaters. No sooner is one break reinforced than the fury of the flood effects another one. The job of protecting the dam is proceeding with the aid of 24 automotive trucks, 450 workers, and 74 'arby'."

The above-described heroic struggle against the elements brings into focus the importance of timely hydrological forecasting.

Hydrological data and forecasting becomes particularly important under the conditions of a planned socialist economy.

They insure the timely preparations for the opening and the discontinuance of navigational seasons, the optimum utilization of the water-level rise in the rivers for downstream timber floating, and the safety of hydroengineering projects along the rivers. Hydrological data is of decisive importance in the planning of current shipping, shiploading, the floating of timber, etc.

Hydrological forecasting relating to the seasonal water volume in the rivers of Central Asia, Transcaucasia, and, particularly, in water-shortage areas, is of the greatest importance in the planning of sowing and irrigation of crops, and is instrumental in the saving of hundreds of thousands of tons of cotton and other industrial crops. The great hydroengineering projects, such as Volkhovges, Dneproges, Zages, Svir'stroy, the White Sea-Baltic Sea Ship Canal, and others, were guided by special hydrological data-and-forecasting services. These special services provided the project managements with the necessary confidence in the progress of the staggering jobs at hand, and resulted in tremendous savings by furnishing timely warnings on impending floods and related hydrological phenomena, the knowledge of which was necessary in the course of construction.

(Footnotes: The Dneprostroy Forecasting Service was initiated in March 1928, and the service for Svir'stroy was created in November 1929.

K. P. Moshins'kiy, The Importance of Hydrological Forecasting to the National Economy; GUEGMS, Ukrainian SSR, Kiyev, 11-12, 1936.)

By the same token, hydrological forecasting is of great importance to the defense of the country. With the up-to-date development and complexity of military science, bodies of water -- as well as the air above -- are potential theaters of war. Hydrological forecasting is a prerequisite of war operations in river areas, since it furnishes valuable data on future happenings. Thus, the width and the flow-velocity of a river at a given time and, consequently, its negotiability by troops and equipment at that particular time are phenomena closely related to the water level, as predicted by the forecasts. The thickness of the ice cover of a river, when properly forecast, facilitates the intelligent planning of the impending military action on the ice. Thus, the newspaper, News of the Soviets of Workers' Deputies USSR, in one of its January 1938 issues reported the case of a Japanese artillery detachment falling through the ice in its attempt to cross a river in Chinese territory. This could have been avoided had the proper hydrological forecast been available to the Japanese command.

§ 2. SOME HISTORICAL FACTS ON THE DEVELOPMENT OF HYDROLOGICAL DATA AND FORECASTING SERICE ABROAD AND IN THE USSR [pp 8 - 13]

The progress of hydrological forecasting, as well as of a number of other sciences, is closely linked to practical demands. The most ancient of the civilized peoples left behind them memorials of hydroengineering construction such as dams, aqueducts, and irrigation systems. There is no doubt that such hydroengineering construction required not only the understanding and knowledge of the current cycle of the bodies of water involved, but also the ability to forecast the cycles to come.

During the period of Napoleon I, a French expedition to Egypt discovered two water-level gauging stations dating back about 4000 years. These gauging stations (nilometers) were under the jurisdiction of the priests, who watched the water marks and forecast the crops by the height of the latter, for upon the Nile attaining its flood stage depended the deposition of the fertile river silts that bore the plentiful crops in the valley of the Nile.

(Footnote: In France, at the beginning of the XVIII century, a water-gauging installation was called a nilometre. See, for example, Thomassy, Essai sur l'Hydrologie, 1859, Paris, page 2.)

However, in historical chronicles we find little reference to the water level and any other forecasting of the hydrological cycle of rivers. On the other hand, in a whole series of books dating back to antiquity, we find elaborations upon the various methods of weather forecasting based upon animal signs, the moon, the stars, and the like.

Thus, hydrological forecasting, as a part of the science of hydrology, has no such elaborate "history" as weather forecasting -- the origin and development of this science pertain to a later day. However, there is no denying that the study of river cycles and attempts at hydrological forecasting were made in the dim past.

Samuil Georg Gmelin, in his Travels over Russia for the Investigation of the Three Kingdoms of Nature , in 1771, writes: "The day of 25 April, as per my experiments, I consider to be the time when the water in the Volga near Astrakhan' begins to rise; a highly dependable sign, following which the above-mentioned change is to come, is the subsequent color of the Volga, which becomes completely white." In other words, Gmelin had observed that an indication of the impending maximum flood stage is a strong turbidity in the water, becoming apparent approximately 20 days ahead of the maximum flood stage, an observation also made by the author throughout the period of 1923-1932.

The oldest known hydrological data and forecasting service was initiated in France, where extensive floods and disasters in their wake emphasized the importance of the problem of forecasting, particularly with relation to the most dangerous rivers. In 1830, an engineer named Belgrand was commissioned by the Government of France to study the possibilities of forecasting the flood stages of the Seine (L. D. Kvitsinskiy, On Forecasting the Fluctuations in the Water Level and the Channel Depth of Rivers, SPB [St. Petersburg], 1896, page 2.). Only after a detailed study of the river's hydrological cycle over a period of 20 years, did he begin to publish experimental forecasts in 1850 for the use of a limited circle of specialists. Parallel studies were made of the Loire, Maas, Garonne, and other rivers. The first forecasting service was organized on the Loire in 1853, on the Seine in 1854, on the Maas in 1864 (Annales des Ponts et Chaussees, 1934, page 409). The forecasting center for the Loire River was in the city of Orleans, where a chief engineer, after studying and coordinating information gathered from the entire basin of the Loire, made forecasts for locations, as established by special regulation.

Officially, however, the service of hydrometric investiand flood forecasting (Service hydrometrique et de l'annonce des crues) was established only in 1876, on the basis of a proposal by the engineer Gross, after the occurrence of an unusual flood in 1875 that caused unprecedented suffering and property damage.

This service was engaged in the study of the rivers of France with a view toward establishing the characteristics of their cycles, general as well as special; knowledge of these characteristics was necessary to insure the proper development of hydrological forecasting. The same service was also concerned with meteorological phenomena with a view toward establishing the link between the hydrological and meteorological phenomena; for example, between the amount of atmospheric precipitation and the water volumes of the rivers, etc.

In Germany, as far back as 1853, simultaneously with the introduction of the telegraph, the foundations were laid for a hydrological data service, concerned primarily with floods of the Rhine, Elba, Oder, and other rivers. And only in 1886 were the first attempts at full-scale forecasting made.

Throughout the period of 1870-1890, Germany suffered several disastrous floods in the basins of the Rhine, Oder, Elba, and other rivers. These forced the creation of some temporary commissions to begin with, and later on, some permanent organizations for the study of the causes of these disastrous floods as well as for the development of countermeasures.

A commission was set up in Baden in 1893, with the engineers Gonzelli and Teyn in charge, for the study of the flood problem of the Rhine.

In Prussia, the special Water Committee (Wasser Ausschuss), which was established after the disastrous floods of 1885 and 1891, was instructed by the Government in 1892 to find the answers to the following direct question: "What are the causes of the recent floods, and does the existing Prussian system of controlling and regulating the rivers constitute a contributing factor to the floods and to the disasters in their wake? If the answer is yes, what are the changes to be introduced into the existing system of river control?"

Under the supervision of the renowned German hydrologist Keller, the Water Committee began the extensive work of investigating the rivers. As a result of this research, the Committee came up with exhaustive answers. These were published in a series of monographs pertaining to the basins of the Oder, Elba, Memel, Pregel, Vistula, Weser, and Ems.

In 1902, the Wasser Ausschuss was abolished, and subsequent research was conducted by the Landanstalt fur Gewasserkunde (Water Economy Control Bureau) in Berlin. Some of the recent research worthy of attention are the investigations of the Oder floods over the period of 1903-1913, and of the problems linked with the construction of reservoirs that control the runoff in the Oder basin. A still more recent work is the detailed monograph by Helmann and Elsner devoted to the summer flooding of the Oder; this monograph establishes the connection between the hydrological processes and the cycle of atmospheric phenomena.

(Footnote: Hellmann, G. and Elsner, Meteorologische Untersuchungen uber Sommerhochwasser der Oder, Berlin, 1911).

It should be noted that hydrological data services were also established in Austria, Sweden, America, Italy, and other countries.

It is also worth mentioning that in Egypt, as far back as 1882, Mahmud-Pasha-El-Falaki, on the basis of brief observations, made attempts to predict the flood stages of the Nile.

In our country, the first attempts at hydrological forecasting were made with relation to water transportation. Three monographs pertaining to hydrological forecasting, written by men concerned with water transportation, were published simultaneously.

(Footnote: /1/ V. G. Kleyber, "Forecasting the fluctuations in the water level and the depth of the sandbanks in the Volga River," read at the III Congress of the Russian waterways Personnel, SPB, 1896. /2/ Gnussin, D. D., "The method of forecasting river levels in the interests of navigation," The Journal of MPS (the Ministry of Communications), No 7-8, SPP, 1897. /3/ Krivtzinskiy, L. I., "The forecasting of the fluctuations in the water level and in the channel depth of rivers," Transactions of the III Congress of Russian Waterways Personnel, SPB, 1896.)

Beginning with 1893, the Kazan' water region of the Ministry of Communications introduced regular telegraphic information on problems of navigation.

The data was telegraphed to Kazan' from Rybinsk, Yaroslave', Kostroma, Kineshma, Gorodets, Nizhniy-Novgorod, Cheboksar, Simbirsk, Samara, Syzran', Vol'sk, Saratov, Tsarits-ya, Astrakhan', Perm', Christopol', and Ufa. From Kazan' the data was transmitted in the form of a telegraphic bulletin to Rybinsk, Nizhniy-Novgorod, Saratov, and Astrakhan'. The telegraphic bulletin indicated: (1) the water level at the water gauge, and (2) the depth and the name of the shalowest sandbank, if, since the previous bulletin, the change in its depth was in excess of 5 centimeters.

Prior to the Great October Revolution, there was very little hydrological forecasting in Russia. Some individual hydrologists placed their forecasts in various departmental memoranda, in publications, in individual booklets, and in special bulletins. This work was conducted in a sporadic manner and without any unified plan.

Within the first decade after the Great October Revolution, such works became somewhat more frequent, but were still few in number. The following forecasts were published:

P. B. Mul'tanovskiy, "The expected height of the flood stage of the Volkhov River in the Spring of 1924," Meteorological Bulletin, No 2, 1924.

A. F. Dynbyuk, "The coming flood and its prognosis for the city of Pereyaslave'-Zalesskiy, Vladimir guberniya, in 1926," Mirovedeniye, No 15, Moscow-Leningrad.

A. M. Rundo, (1) "The level of Lake Ladoga in 1922,", GGI, Petrograd, 1922; (2) "The impending summer levels of the Ladoga and Onega lakes," Bulletin of the Northwestern Bureau of Water Transportation, No 15, 1922, Petrograd.

P. M. Yerokhin, "The impending water level at the lower reaches of the Don River for the spring of 1928," Bulletin of the North-Caucasian Railway, Rostov-on-the-Don, No 13, 1928.

N. Georgiyevskiy, (1) "The snow cover and the prospects of the spring flood for 1928," Bulletin of the North-Caucasian Railway, Rostov-on-the-Don, No 13, 1928; (2) "The impending flood for the spring of 1929," Bulletin of the North-Caucasian Railway, No 10, 1929.

Following the Great October Revolution, the coordinated and planned development of the national economy of the country called for ever growing hydroengineering construction, which in turn called for more hydrological forecasting. The departments began to show interest in hydrological forecasting, and the literature devoted to this problem was considerably expanded.

Special hydrological forecasting cells were established in a number of organizations. In the Central Office of Maritime Transportation, V. Yu. Vize was concerned with the problems of ice forecasting, and later on, in 1922, the V. N. Lebedev cell was set up at the State Hydrological Institute for the purpose of hydrological forecasting. In the Ukraine, beginning with the end of 1923, the hydrometeorological subsection of the meteorological service developed new methods for the forecasting of the water levels in the Dnepr -- methods differing from those of V. N. Lebedev; also, a number of specialists, Ol'dekop, Davydov, Bydin, Ogiyevsky, Nazarov, Mashukov, Mashkevich, the author, and others, became engaged in hydrological forecasting in various areas of the USSR. The growing necessity for a better organization of this service is reflected in a series of articles on the subject such as the following:

E. Ol'dekop, "The low-water condition of the Turkestan rivers in the summer of 1917 as related to the meteorological conditions of the preceding winter season," Bulletin of the Turkestan Hydrometeorological Bureau, No 2-3, 1917. In the same Bulletin, "The problem of forecasting low-water conditions in the rivers of Turkestan."

L. K. Davydov, "Immediate problems for the establishment of forecasting service pertaining to the low-water condition of the Turkestan rivers," Irrigation Herald, No 6, 1924, Tashkent.

A. V., "Experimental forecasting of the ice break-up in navigable rivers," Timber Industry, No 12, 1927, pages 3436,

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I. P. Popov, "Flood problems in Turkestan and in North America," Irrigation Herald, Nos 1 and 5, 1924, Tashkent.

A. K., "The ice break-up in the Northern Dvina in 1917 and the establishment of forecasting service," Meteorological Herald, Nos 11-12, 1917, Petrograd.

A. M. Rundo, "Forecasting the summer levels of Ladoga and Onega lakes," Bulletin of Mariin Oblast, Board of Waterways, No 26, 1920, M.

N. K. Rodionov, "The problem of the annual floods and the land-eroding flood waters and the forecasting of same," Irrigation Herald, No 2, 1930, and others.

Finally, in 1930, a special hydrological forecasting service was established at the Central Weather Bureau USSR. In May 1932, a conference took place in Leningrad pertaining to the long-range weather and hydrological-cycle forecasting. In January 1934 there was a consultation in Moscow at the Central Weather Bureau USSR pertaining to hydrological forecasting service for the cotton-growing areas.

Beginning with 1934, the academic plan of the Moscow Hydrometeorological Institute called for a course in hydrological forecasting and data-gathering to be conducted by the author of this book. In 1935, hydrometeorological forecasting was introduced into the curriculum of the Moscow Hydrometeorological Technicum, and, finally, in 1937, the author was assigned a regular course in hydrological forecasting at the Khar'kov Hydrometeorological Institute.

Beginning with 1938, a series of conferences on hydrological forecasting took place at the State Hydrological Institute. The decisions made at these conferences are discussed in the corresponding subdivisions of this book.

At the present time, the development of hydrological forecasting methods is under the jurisdiction of the State Hydrological Institute in Leningrad and the local offices of the Hydrometeorological Service.

Hydrological forecasting is now one of the leading activities in the system of hydrometeorological service. There are annual study courses for the training of hydrological forecasters. The number of hydrological forecasts published annually has now reached 50,000.

The development of hydrological forecasting is due to practical requirements. It has turned out to be a profitable venture, i.e., the expenditures for the organization and maintenance of the service has brought good returns in terms of great benefits accrued.

Under the conditions of the planned socialist economy of the USSR, the demand for hydrological forecasting must be particularly great.

However, regardless of the wide expansion of the hydrological data and forecasting service, it still does not satisfy completely the requirements of the national economy and the defense of the USSR.

As a result of the lack of long-standing experience and of a well-developed methodological base, as well as, at times, the inconsistencies in the distribution of the hydrosynoptic network and the shortages in qualified personnel, the forecasts furnished are not always reliable.

At the present time, forecasting is done primarily with relation to the maximum and minimum water levels, to the discharges of rivers, to the dates of the breaking of the ice and the solid freezeovers of rivers. The national economy and the defense of the country cannot be fully served by the prediction of solely individual elements of the cycles of the rivers. They are in need of a systematic prognostication of a group of interrelated elements pertaining to definite dates, which in turn are linked to the particular needs of the respective branch of the national economy or of the defense of the country.

§ 3. THE PURPOSE OF A TEXTBOOK ON HYDROLOGICAL DATA AND FORECASTING [pp 13-16]

The word "prognosis" is Greek: πρὸ -- ahead of time, γνῶσις* -- knowledge, i.e., the knowledge ahead of time of what is

* [Note: In the Russian original this Greek word was incorrectly written as: γνόσισ, which shows 3 glaring errors, as seen by comparison with the correct form: γνῶσις.]

to come. Hydrological forecasting is a science permitting the determination of hydrological processes which are to take place in the future.

Hydrological data-gathering and forecasting is closely involved with the knowledge of the river cycle and of the effect upon this cycle of meteorological, climatic, and geographical factors. Consequently, by the preceding hydrometeorological environment, against the backdrop of a definite geographical landscape, computations can be made, and a well-founded prognostication of the future magnitude of the river discharge and other hydrological characteristics of the river cycle, together with the date of occurence, can be ascertained.

The study of past and present hydrological phenomena and the establishment of a genetic link between them is still a problem, which, in many cases, defies solution. As a result of that, the processing of hydrological forecasts, in view of the inadequate knowledge concerning some of the component items, presents considerable difficulties.

Hydrological forecasting, in determining the characteristics of the river cycles to come, constitutes the highest form of hydrological knowledge. This requires thorough hydrological training, a firm familiarity with the fundamentals of hydrology and meteorology, a good understanding of the basic synoptic processes and how they evolved, and a firm knowledge of the past hydrological data pertaining to the river cycle.

Physico-mathematical sciences, geography, hydrometry, hydrology, meteorology, hydrological computations, synoptic analysis, hydrological forecasts -- all these constitute the step-by-step path to the knowledge of the future hydrocycle of the rivers.

Hydrometry furnishes the basic data for hydrological forecasting. The incessant improvement in the methods of hydrometric observations is a prerequisite for good hydrological forecasting.

The modern methods developed by Sherman, Berle, call -- in a number of instances -- for water level and atmospheric precipitation data to be registered by self-recording instruments.

Hydrological computations, by continuously improving methods, make for greater precision in calculating the water economy of reservoirs, the amount of precipitation, evaporation, the movement of the waters along the basin surfaces, the moisture-saturation of basins, etc. All these, in turn, make for a higher degree of precision in forecasting.

Regardless of the great difficulties of weather forecasting, attempts are now being made to derive direct precomputations of the weather to come.

(Footnote: For instance, in the books by (1) V. Bjerknes, Dynamische Meteorologie und Hydrographie, Teil 2, Braunschweig, 1912; (2) L. Richardson, Weather Forecasting by Numerical Processes, Cambridge, 1922; (3) recent works of Soviet scientists

/Kibel', Dorozhnitsyn, and others/ on the application of hydrodynamics.)

It is absolutely clear that the new methods will also find application in hydrology, where, in some cases, the future water levels and other elements of the water economy will be computed with the requisite precision.

A forecast must, if only possible, be based on the study of the formation processes of hydrological phenomena, and on genetic computations of same. In the study of hydrological phenomena for the purpose of forecasting, it is first necessary to differentiate these phenomena, then to establish the causal relationships between the elementary phenomena and their conditioning factors, following which a synthesis is to be made.

Each river has its peculiar characteristics calling for a special approach and study. S. P. Khromov, in his Introduction to Synoptic Analysis, writes: "The weather can be forecast only by way of study and understanding, but not by the mechanical follow-up of ready-to-use patterns." This is equally true in the case of hydrological prognostication.

An up-to-date hydrological forecast requires the computation of the ratio between a variable, which characterizes some hydrological phenomenon (the crest of a flood, the date of the ice break-up, the date of the solid freezeover, etc) and a series of other variables, the effect of which is implied om the basis of modern physical concepts.

Any attempt at the construction of a link between phenomena at random, without any physical substantiation, is without reason, even though a "lucky guess" may sometimes occur.

Up to now, hydrological forecasting was done primarily by statistical methods based on the utilization of long series of observations, and only recently are physically substantiated methods of forecasting being developed. Hydrological forecasting in the USSR, having begun only recently, combined with little knowledge of the processes involved, accounts for the initial wide use of statistical methods.

The above-said pertains not only to the long-range forecasting of water levels, but also to the forecasting of the river discharge, where the genetic links are clearer and simpler. Even in the prognostication of the horizons of adjacent observation points, the movement of the water masses was never taken into account. Under such conditions, the difficulties of publishing a textbook on hydrological forecasting, which is still further complicated by the absence of uniform opinions among hydrologists on the subject of forecasting, are fully realized by the author. Neverthless, the publication of such a textbook has long been a necessity, and the attempt must be made.

Although the desire of the author to construct the textbook on hydrological forecasting predominantly on genetic considerations, on the condition of continuity in the movement of the masses of water, on the equations governing the water economy, has not been fully realized, the orientation toward the above principles has been firmly established, and the author expects that time and collaboration with the hydrologists engaged in forecasting will bring about the fuller accomplishment of the above in the future.

The present textbook presupposes an adequate understanding of the theoretical fundamentals of hydrology, hydraulics, statistics, and other auxiliary sciences. Its purpose is to present, in all possible detail, the forecasting methods, published as well as unpublished, that are used in modern practice.

The first part of the textbook is devoted to hydrological data, which generally is not available in print, yet is of great importance to the extent that hydrologists on location devote more than half of their time to its analysis.

The second part of the textbook on hydrological forecasting deals with the methods for the study of the movement of water masses in river basins and channels, taking into account their peculiar characteristics which may be used for purposes of forecasting. In those cases where hydrology has not yet embarked upon the path of the genetic understanding of the processes involved, but the needs of the national economy and of the defense organs of the country call for prognostication, statistical methods of forecasting, utilizing the principles of mathematical statistics and other procedures, with some reservations as to the degree of reliability, are employed.

Considerable assistance in seeing this assignment through was furnished to me by Professor M. I. Martselli in the form of extremely valuable advice and extensive work involved in the editing of the book.

Acknowledgement is hereby made for the guidance furnished by the following persons and offices: Major General E. K. Fedorov, Chief, GUGMS USSR; Comrade V. F. Pushkarev, Head, Hydrological Bureau; Professor E. V. Bliznyak, Doctor of Technical Sciences; B. P. Orlov, Doctor of Geographical Sciences; the State Hydrological Institute; O. T. Mashkevich and V. L. Nikitin, hydrological engineers. Also to V. S. Grigor'yev for valuable advice and responsible editing.

The graduation theses of our young hydrological engineers graduating from the Moscow Hydrometeorological Institute were also of great help, the appreciation of which is hereby expressed. The names of this younger work corps are as follows: V. V. Orlova, E. P. Snigireva, F. M. Molokov, K. I. Mel'nikov, N. A. Kabarov, and others.

Considering the imperfections inherent in some forecasting methods and the circumstance that no check on the accuracy of some forecasts was available, the lack of a thorough evaluation in such cases should be understandable. Hydrologists engaged in forecasting know the amount of time consumed in the thorough evaluation of data, the pursuit of which would considerably retard the publication of the book. Hence, in using any method of prognostication, they are to check its effectiveness by using the data available over a prolonged period, and only in the case of positive accuracy are they to introduce it into practical use.

Highly aware of all the above-enumerated difficulties, we cannot consider this book to be without defects. However, with the aid of our fast-growing collective of hydrologists, it is hoped that these defects will be gradually eliminated. And since no textbooks on this subject are as yet available, we are confident that this text is necessary and will turn out to be useful to our country, serving at the same time as a preliminary step in the preparation of better textbooks on hydrological prognostications.

[END OF 'INTRODUCTORY NOTES' OF BOOK]

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