The Ohio Surface Water Survey

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None too soon, Ohio has begun to measure the flow of its streams accurately. The state has been singularly backward in this respect, for although it has been in advance of all other states west of the Alleghenies in completing a topographical survey of its entire area in co-operation with the National Government, very little, in contrast with sister States, has been accomplished in stream flow measurement.

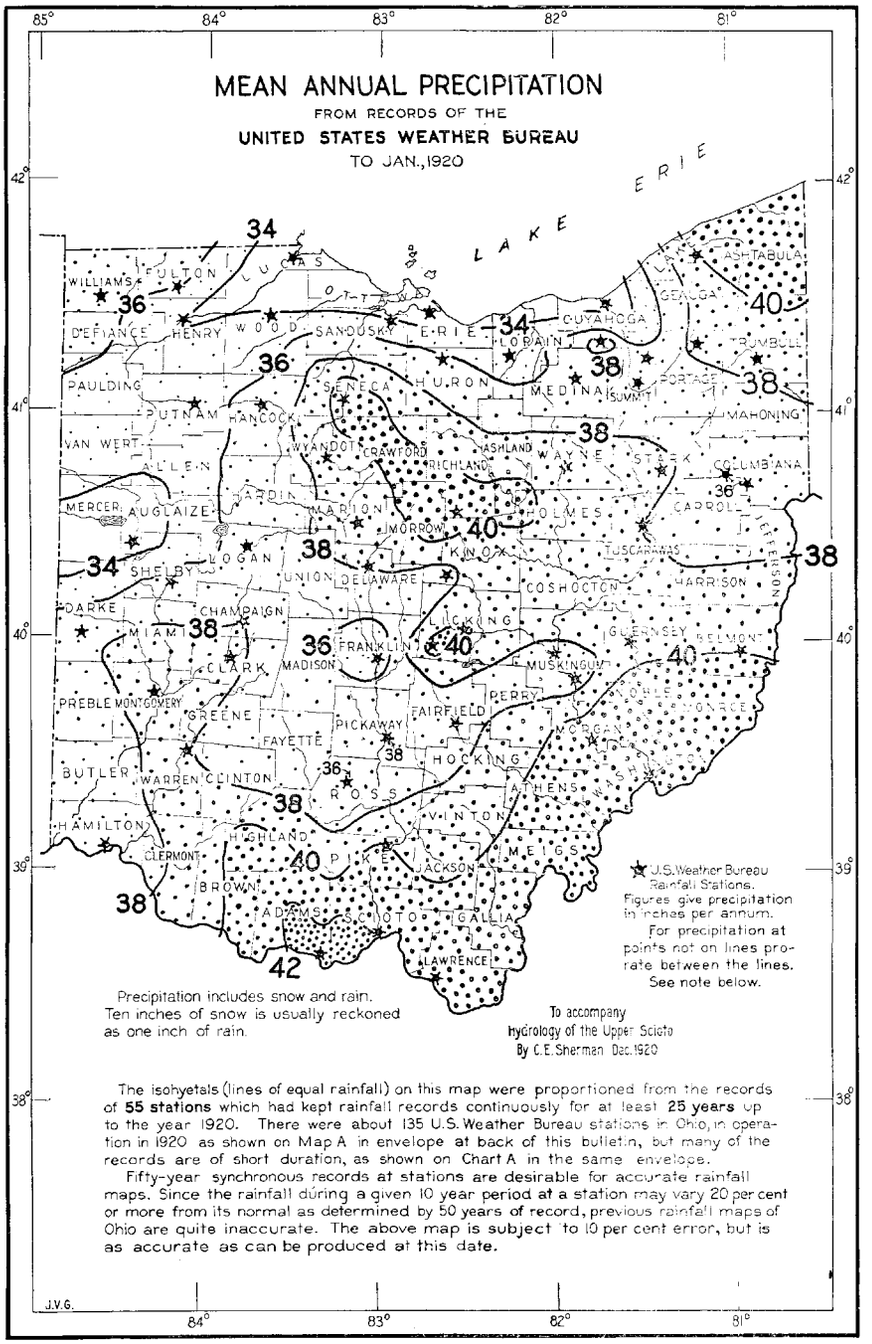

Fig. 1

It is true that the United States Weather Bureau has established many staff gauges throughout the state where elevations of the water surface are read daily throughout the year, and the Bureau has just installed an automatic self-recording gauge at the new Broad Street Bridge over the Scioto at Columbus. But the observations of the Weather Bureau record merely the surface height of the water and not the volume of water passing the gauge. Furthermore, the gauge heights at low water have not been accurately read because the purpose of the Weather Bureau readings is primarily to forecast floods. This is a valuable service at times of high water, but the period is rapidly approaching for some streams—is already here for others—when the minimum flow of streams is to determine what industries shall locate on them, and what ultimate limits they shall set to the growth of the cities on their banks.

At the last session of the Legislature an appropriation was made to co-operate with the Water Resources Branch of the United States Geological Survey in gathering Hydro-Metric data for Ohio streams. Although the amount was small—$12,000 biennium—a good start has been made and about 35 of 45 contemplated stations have been established. This much has been made possible by the co-operation of the Weather Bureau of several Public Utilities, the University, an allotment by the National Government, and by placing the State's portion of administration under the Topographic Survey, which is completing the 4-volume final report on the latter work.

Mr. N. C. Grover, Chief Hydraulic Engineer of the Water Resources Branch last July designated Mr. Lasley Lee as the District Hydraulic Engineer to take charge of the work, and the University has furnished quarters on the balcony floor of Orton Hall. All regular employes are furnished through the U. S. Civil Service Commission.

Much progress has been made on the art of stream measurement during the past fifteen years, during which time Ohio has done next to nothing in such work. Improved chain gauges are now used in connection with enameled steel staffs which enable low water heights to be read easily to hundredths of a foot. The former practice of reading to tenths or half-tenths, which is high enough for high water stages, often resulted in errors of 50% or more in calculating low water discharges.

Much more attention is now paid to the location of the gauge, which must not be adversely affected by backwater, nor by pooling of dams, artificial or natural, and which must yet be so located that the entire flood flow, and of course low water flow, can be readily ascertained. Other factors enter into the location also, but those above named make it difficult to gauge some streams. Killbuck Creek, for example, which has a drainage basin of nearly 700 square miles, offers too much difficulty to accurate gauging at present.

It is proposed to gauge every stream in Ohio having a 1,000 mile basin although it is necessary to measure some streams having larger and some having smaller basins than this standard. A number of thriving cities in Ohio are at present dependent upon a much smaller basin area than 1,000 square miles for their water supply. While nearly all these cities are growing rapidly, it seems almost certain that limits will be set them by the size of tributary drainage basins, because raw water must be furnished by gravity to be cheap, and there is only one ultimate source of supply—the clouds.

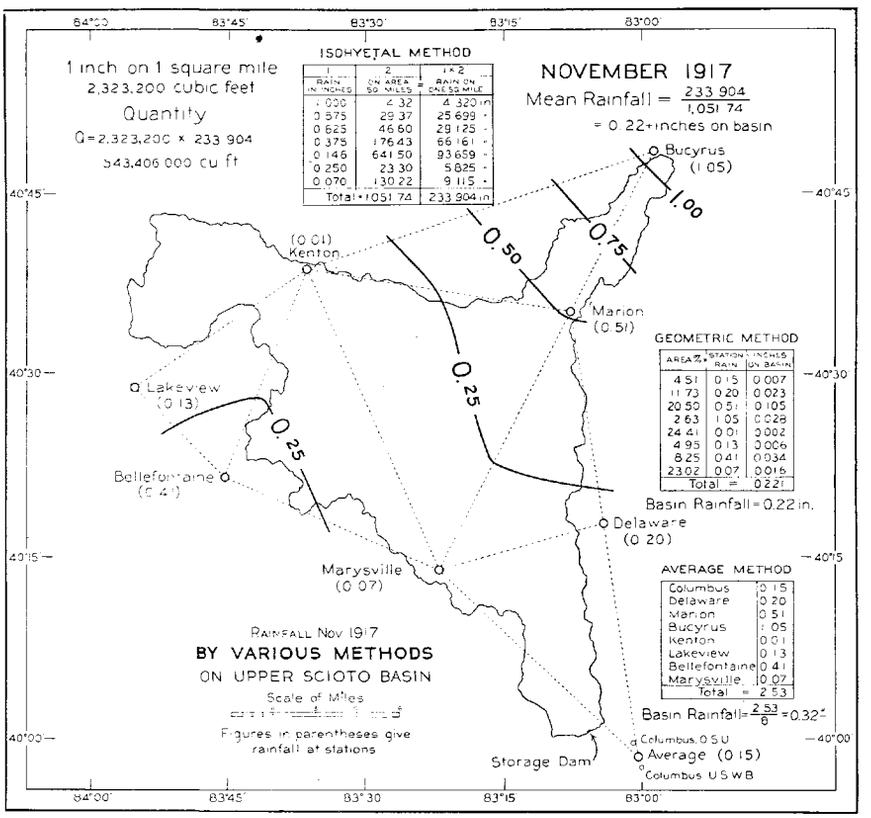

Fig. 2

Under past methods a series of measurements extending over several decades is necessary before the regimen of a river becomes well enough known to treat it economically for modern purposes, such as for city water supply, water power development, flood mitigation, sewage dilution, and for location of manufacturing plants requiring large amounts of condenser or cooling water. Evidently the maximum flow of a stream, its minimum flow and periodic variations from these extremes should be known with reasonable accuracy before it can be treated for any of the foregoing purposes without wasting great sums of money.

Suppose for instance that the water supply of the Panama Canal should prove inadequate eventually to handle the maximum tonnage for which the locks were designed. How much money would have been wasted for lack of long time stream

studies of the Chagres River? It is not meant to insinuate that there will not be enough water there, but the stream flow studies of the Chagres do not cover accurately very many years.

It is better to take an example closer to home. At Austin, Texas, the losses due to inadequate preliminary study of the Colorado River have to date totaled several millions of dollars. True, part of the losses have resulted from inadequate study of bedrock at the site of the dam and power house, and part from lack of study of the silt carrying quality of the stream, but enough of the loss is still chargeable to the lack of preliminary information as to the amount of stream flow, to have paid for stream guaging over the entire state for a number of years.

Coming still closer to home it is interesting to know that recently a million dollar manufacturing plant would have located on an Ohio stream if it could have been shown that its dry weather flow was not less than 500 cubic feet per second. Information was lacking to determine this point although the tributary basin was five or six thousand square miles.

Many more specific instances of direct loss can be cited in Ohio and adjoining states, which demonstrates the increasing necessity for careful Hydro-Metric data. Past losses in water power plants have furnished the most striking examples of justification of expenditure in making stream flow studies, and will not be listed because they are well known to hydraulic engineers.

The whole study of streams, their flow and flow relations to precipitation, geology, topography, evaporation, temperature, vegetation and cultivation, silt carrying qualities and chemical characteristics of the water, has sprung into great importance in those regions thickly settled like Ohio, and is included in this science of Hydrology. Indeed in many a region the water in the streams is by far the most important single mineral resource of the region.

It has been said that the long time flow records are needed—the longer the record the better for economical treatment of stream. Since low-water conditions govern manufacturing operations, city water supplies, water power installation and sewage disposal by dilution, while high water conditions govern the levee heights, bridge clearances, and highway and railway locations where these communications follow river valleys, it is important that the river records cover highest and lowest water as well as indicate closely the behavior of the stream in the interim.

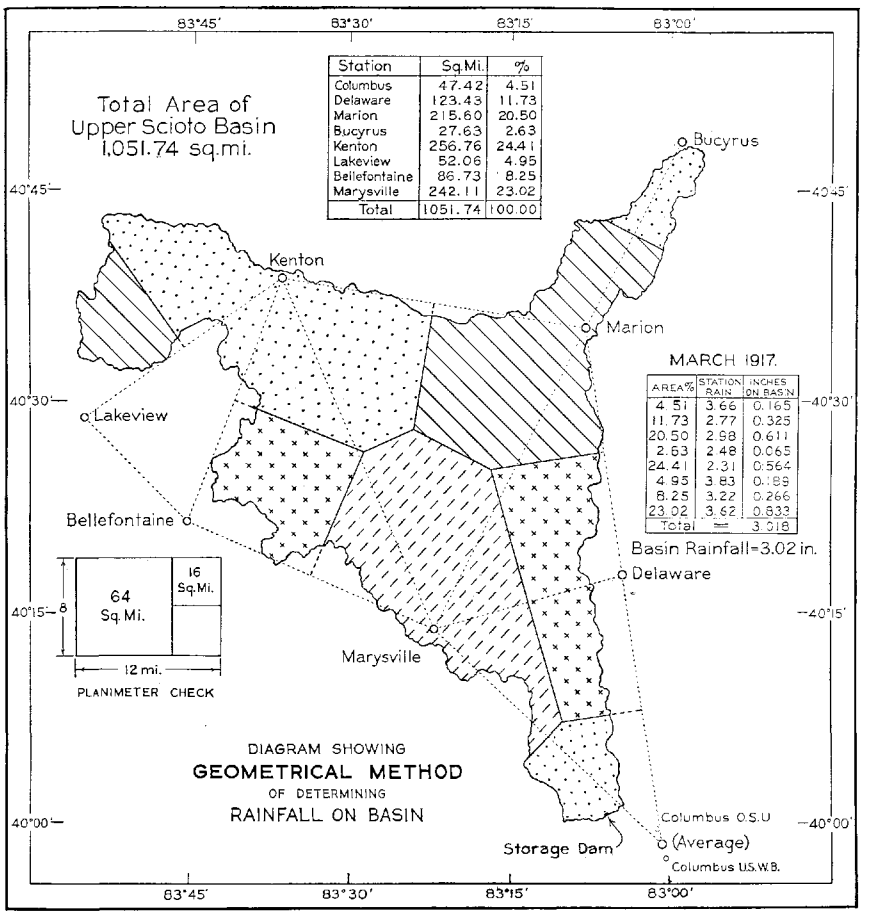

Fig. 3

Thus if the regimen of the Olentangy River which flows through the University grounds were well known it would save thousands of dollars in the improvements soon to get under way.

Since highest and lowest water may occur many years apart a record of river heights for a few years only is an uncertain guide. Will we have to wait until present river operations are continued many years into the future?

Many attempts have been made by hydraulic engineers to obivate this difficulty. The most popular method has been to try to fit the case by formula. Of these, formulas for flood flow are

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most numerous, but also formulas and graphs for minimum flow have been used. The factors that have to be assumed in these formulas for each basin therefore are too uncertain to give satisfactory results. Another method is to use the regimen of one stream from which to pro-rate the flow of others in its vicinity. This by way of example would lead to gross error in judging the regimen of the Olentangy from that of the Scioto, although the two streams lay side by side and seem to be similarly situated.

A recently suggested method of much promise is to use the detailed information concerning, snow, rain, temperature and evaporation on a given basin, gathered by the United States Weather Bureau, together with the agricultural, topographic and geologic characteristics of the basin determined from other sources, coupled with the stream flow measurements extending over only a few years, to determine co-efficients which may safely be applied over the period during which the Weather Bureau has kept adequate record. Since the latter Bureau has extensive records, this method, though laborious, would be of great value should it prove to be successful.

Ohio seems to offer the best opportunity of any State in the Union to adequately test the foregoing method. This is because it is comparatively well supplied with voluntarly U. S. Weather Bureau Stations having fairly long records quite evenly distributed over the State. Also some stream gauging has been done from which to derive co-efficients, the most notable instance being that of the Storage Dam, which after 4 or 5 attempts was finally calibrated as a weir, thus making ten years of recorded water heights on the crest available for careful studies.

The foregoing method and other closely allied matters is the subject of a bulletin entitled "Ohio Stream Flow with special Reference to the Hydology of the Upper Scioto" now being prepared by the engineering experiment station for publication next summer. The bulletin will contain numerous cuts and charts, several of which are here reproduced.

As an illustration of some of the points to be brought out in the bulletin, attention is called to the very common mistake in calculating rainfall on a basin, by using the average of the rainfall at each station on or near the basin. Thus, for November, 1917, if the average is taken of the eight station observations shown, the result is in error by 40% or more as calculated by the isohyetal and geometric methods.

The isohyetal method of calculating rain fall on a basin is shown in the cut for the month of November, 1917. It is probably the most accurate of all methods but is very laborious, because a separate map with attendant planimeter scalings has to be drawn for each month. The geometric method checks very closely with the isohyetal method and saves an immense amount of labor where a long term of years has to be studied, because only one map with attendant planimeter scalings needs to be used so long as the same rainfall stations report each month.