Circular No. 4.

INSTRUCTIONS FOR MEASURING THE RATE OF EVAPORATION FROM WATER SURFACES.

ISSUED BY THE U. S. GEOLOGICAL SURVEY.

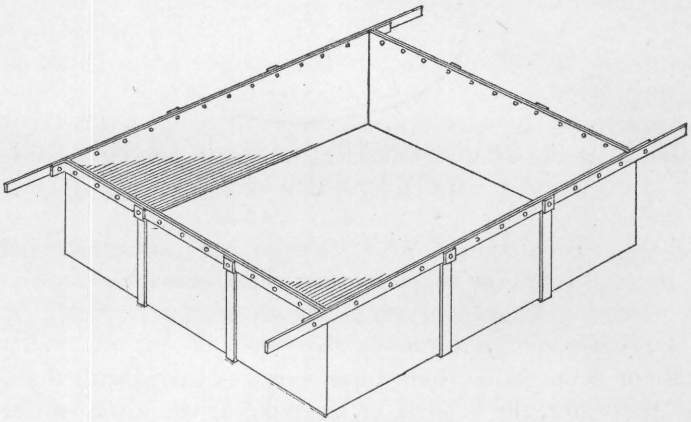
The rate of evaporation from water surfaces varies with the temperature of the water, the velocity of the wind at the water surface, and the dryness of the air. Consequently, the rate of evaporation from rivers, lakes, canals, or reservoirs varies widely in different localities and for the same locality in different seasons.

The method adopted for measuring the evaporation from a body of water consists in measuring the loss of water from a pan which is so placed that the contained water has, as nearly as possible, the same temperature and exposure as that of the water which it is intended to represent. If this could be perfectly accomplished, the observation would give directly the rate of evaporation desired; but since the inclosing of the water in the pan tends to change its temperature and exposure, the observation is an indirect one. And in order to know how closely it represents the evaporation from the natural water surface, the observations must include the water temperatures and the wind force from which the difference of temperature and exposure may be estimated.

DESCRIPTION OF THE EVAPORATING PAN.

The evaporating pan used by the Geological Survey is of galvanized iron, 3 feet square and 10 inches deep. Around the top of the pan on the outside is riveted a strip of band iron. Four additional strips of band iron riveted to the top piece are then bent around under the pan, two strips in each direction, thus furnishing the necessary stiffness. Instead of strips of band iron, cross-pieces of scantling may be placed under the pan and fastened to the band iron around the top with long bolts of round iron. In either of these ways the pan may be stiffened so that it will preserve its shape without being riveted except along the top edge. The pan is floated by two galvanized iron pontoons, 4 feet long and 9 inches in diameter, and strengthened in the middle by braces. On opposite sides of the pan the band iron around the top projects a

distance of 6 inches to form pairs of arms by means of which the pan rests on the pontoons. (See accompanying diagram.)



LOCATION AND EXPOSURE.

In order that the rate of evaporation from the water in the pan shall be the same as from the body of water which it represents, it must maintain the same temperature and be exposed to the same wind velocity. These conditions can be most nearly attained by floating the pan in the water at a place where the wind velocity is an average, or, in occasional cases, by sinking the pan nearly to the top in very marshy ground. In general the condition that the pan should be in a place of average wind velocity must be sacrificed to a practical requirement, namely, that the water about the pan when it is floated shall be still enough to enable an accurate observation of its height to be made. The location should therefore be chosen with the view of securing a body of relatively quiet water around the pan. The pan should be so fastened or secured that it can not drift into shallow water where it would be grounded and partly overturned.

HEIGHT OF WATER IN THE PAN.

A further change in exposure incident to the use of an evaporating pan arises in the cutting off of the wind from the water surface by the sides of the pan, the effect being greater the lower the water in the pan. In consequence the pan should be filled as full as is consistent with security against overflow.

GRADUATED SCALE FOR MEASURING THE WATER HEIGHT.

The device used for determining the amount of evaporation consists of a series of inclined brass scales attached to a vertical frame, and the whole screwed to a light wooden cross-bar which rests upon the sides of the pan.

These scales, which are intended only for differential measurements, are graduated downwards from the top for every .05 inch of vertical height. Thus a lower height of water has a higher reading on the scale.

METHOD OF USING THE SCALE.

When an observation is to be made, the scale should be placed across the middle of the pan, the ends of the cross-bar always resting at the same points on the sides. To find these points easily they should be distinguished by a mark. After the water has become as quiet as possible the height on the scale is to be observed. When the water is perfectly quiet it can be seen that the surface of the water around the scale is raised appreciably by capillarity. The point on the scale which represents the natural undisturbed level of the water is that at which the surface is seen first to be broken by the scale, and from which the curved surface produced by the capillary action is seen to rise. When this point is between the graduations of the scale, a little experience will enable the observer to interpolate it to the nearest .01 inch. If the surface of the water cuts the inclined scale close to the end, its capillarity with the adjoining vertical frame so alters its position that the observed height can not be relied upon as representing the true level. The pan, therefore, should always be filled to a point such that the surface of the water will be along the middle parts of the inclined scale; and similarly, after the surface has been lowered by evaporation, a refilling should not be made when the water cuts the scale near the vertical frame. After every observation the scale should be taken out of the water and kept in a dry place to preserve its brightness.

OBSERVATION OF WATER TEMPERATURES.

Thermometers will be furnished for observing the temperature of the water both in and out of the pan. In making this observation the bulb of the thermometer should be inserted beneath the water surface so that it is entirely covered, and after waiting a moment for the thermometer to attain the water temperature, the reading should be made while the thermometer is in that position. In no case should the reading be taken after the thermometer is removed from the water. For the best results the temperature should be observed in the early morning, when the temperature in the pan is generally lower than that outside, and late in the afternoon, when it is generally higher.

The observation should be made as nearly as practicable at the same hours each day.

OBSERVATION OF WIND FORCE.

As the wind is one of the most important elements affecting the rate of evaporation, a record of its highest force each day is a valuable addition to the observations. Space and instructions for recording it are given on the blanks furnished for the observations.

ROUTINE OF OBSERVATIONS.

Having established the pan in the location selected, the first observation consists in reading its height on the scale in the manner above

described. Care should be taken that the pan be entirely afloat when the reading is made, for any grounding of the pan would so change the position of the surface of the water as quite to vitiate the observation. At the next observation the temperatures are to be observed as already described and the new height of the water surface taken. The observations should continue in this manner until the water has fallen about two inches, when the pan is to be refilled. The refilling should be made only after the height of the water and the temperatures are carefully taken and recorded. A refilling should never be made at a time when, on account of wind or for other reasons, the water height can not be accurately observed. After refilling, the new height of the water surface should be recorded. The difference between the height of the water at any observation and the height at the preceding observation should give the evaporation for the interval, unless rain-fall has occurred. In this case, in order to compute the evaporation, the amount of rain-fall is to be added to the height of the water before subtracting the height at the preceding observation from it.

A rain-gauge will be furnished to obtain the amount of rain-fall, and the measures should be made in accordance with instructions for rain-fall observations.

If it is raining at the usual time of measuring the evaporation, the observation may best be postponed until the rain-fall has ceased. The following example illustrates the method of computing the evaporation in case of rain:

June 26, 7 a. m.

Height of water on scale	1.32
Rain since last observation	.12
Total	1.44
Height at previous observations	1.36
Evaporation	.08

When only a slight rain occurs this method of taking account of the rain is usually satisfactory, but when a heavy storm occurs, generally no results at all can be obtained. The pan must be put in order after the storm and a new start made.

The best results accrue when the evaporation can be measured daily, but results of value are obtainable when observations can be made only at longer intervals.

In districts where the water contains a large amount of alkali in solution the pan should be entirely emptied at occasional intervals and filled anew.

The preceding explanation of instruments and instructions for their use contain all the information requisite for the guidance of the observer, but the successful conduct of the observations requires his continued watchfulness and care.

WASHINGTON, D. C., *August* 1, 1889.

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