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Chapter A7

STAGE MEASUREMENT AT GAGING STATIONS

By Thomas J. Buchanan and William P. Somers

Book 3

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PREFACE

The series of manuals on techniques describes procedures for planning and executing specialized work in water-resources investigations. The material is grouped under major subject headings called books and further subdivided into sections and chapters; Section A of book 3 is on surface-water techniques.

The unit of publication, the chapter, is limited to a narrow field of subject matter. This format permits flexibility in revision and publication as the need arises.

Provisional drafts of chapters are distributed to field offices of the U.S. Geological Survey for their use. These drafts are subject to revision because of experience in use or because of advancement in knowledge, techniques, or equipment. After the technique described in a chapter is sufficiently developed, the chapter is published and is sold by the U.S. Geological Survey, 1200 South Eads Street, Arlington, VA 22202 (authorized agent of Superintendent of Documents, Government Printing Office).

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Abstract

Continuous measurements of stream stage are used in determining records of stream discharge. In addition a record of stream stage is useful in itself, as in designing structures affected by stream elevation or in planning the use of flood plains.

This report describes instruments and structures commonly used in obtaining a record of stream stage.

Introduction

The stage of a stream or lake is the height of the water surface above an established datum plane. The water-surface elevation referred to some arbitrary or predetermined gage datum is called the gage height. Gage height is often used interchangeably with the more general term stage although gage height is more appropriate when used with a reading on a gage. Stage or gage height is usually expressed in feet and hundredths of a foot.

A record of stream stage is useful in itself, as in designing structures affected by stream elevations or in planning use of flood plains. In stream gaging, gage heights are used as the independent variable in a stage-discharge relation to derive discharges. Reliability of the discharge record is therefore dependent on the reliability of the gage-height record as well as the stage-discharge relation.

Gage-height records of lakes and reservoirs provide in addition to elevations, indexes of head, contents, storage capacity, and other properties.

Gage-height records may be obtained by a water-stage recorder, by systematic observation of a nonrecording gage, or by noting only peak stages with a crest-stage gage. Telemetering systems are used to transmit gage-height information to points distant from the gaging station.

Datum of gage

The datum of the gage may be a recognized datum, such as mean sea level, or an arbitrary datum plane chosen for convenience. An arbitrary datum plane is selected for the convenience of using gage heights of relatively low numbers. To eliminate the possibility of minus values of gage height, the datum selected for operating purposes is below the elevation of zero flow on the control for all conditions.

A permanent datum must be maintained so that only one datum for the gage-height record is used for the life of the station. To maintain a permanent datum each gaging station requires at least two or three reference marks that are independent of the gage structure. All gages are periodically checked by running levels using the reference marks to maintain a fixed datum.

If an arbitrary datum plane is used, it is desirable that it be referred to a bench mark of known elevation above mean sea level by levels so that the arbitrary datum may be recovered if the gage and reference marks are destroyed.

Sensors of water level

Water level is sensed by a float in a stilling well or by a gas-purge system which transmits the pressure head of water in the stream to a manometer. The later system is known as a bubble gage.

Float Sensor

The float sensor consists of a tape or cable passing over a pulley, with a float in a stilling well attached to one end of the tape or cable and a counter weight to the other. (See fig. 1.)[1] The float follows the rise and fall of the water level, and the water level can be read by using an index and graduated tape, or the pulley can be attached to a water-stage recorder to transmit the water level to the recorder.

Bubble-gage sensor

The bubble-gage sensor (Barron, 1963) consists of a gas-purge system, a servomanometer assembly, and a servocontrol unit. (See fig. 2.)

The gas-purge system transmits the pressure head of water in the stream to the manometer location. A gas is fed through a tube and bubbled freely into the stream through an orifice at a fixed elevation in the stream. The gas pressure in the tube is equal to the piezometric head on the bubble orifice at any gage height.

The servomanometer converts the pressure in the gas-purge system to a shaft rotation for driving a water-stage recorder. Mercury is used as the manometer liquid to keep the overall length to a minimum. The manometer has a sensitivity of 0.005 foot of water and can be built to record ranges in gage height in excess of 120 feet. The use of mercury in the manometer permits positioning of the pressure reservoir to maintain the float-switch contacts in null position. In this position, the vertical distance between mercury surfaces will be 1/13.6 times the head of water. A change in pressure at the reservoir displaces the mercury which in turn activates the float switch. This causes movement of the pressure reservoir until the distance of head of water divided by 13.6 is again maintained. This motion in turn is translated to the recorder.

The servocontrol unit provides the relay action necessary to permit the sensitive float switch to control the operation of the servomotor and also to provide an appropriate time delay between the closing of the float switch and the starting of the motor.

The proper placement of the orifice is essential for an accurate stage record. The orifice should be located where the height of water above it represents the stage in the river. If it is partly buried in sand or mud, the recorded stage will be greater than that in the river. An orifice preferably should not be installed in swift currents. If this is unavoidable, it must be kept at right angles to the direction of flow. A recommended mounting for swift-flow conditions is for the orifice to be mounted flush with the wall of the mounting structure. Care should also be taken to keep the orifice out of highly turbulent flow.

Water-stage recorders

A water-stage recorder is an instrument for producing a graphic or punched tape record of the rise and fall of a water surface with respect to time. It consists of a time element and a gage-height element which, when operating together, produce on a chart or a tape a record of the fluctuations of the water surface. The time element is controlled by a clock which is driven by a spring, by a weight, or by electricity. The gage-height element is actuated by a float or a bubble gage.

If a float sensor is used, the float pulley is attached to the recorder. The float and counterweight are suspended on a perforated steel tape or on a plain or beaded cable. Cone-shaped protrusions on the circumference of the float-tape pulley match perforations in the tape. As the float rises or falls the float pulley turns a proportional amount, thereby changing the gage-height reading on the recorder. A copper float 10 inches in diameter is normally used, but other sizes are used depending on the type of recorder, gage-height scale, and accuracy requirements.

[1] Figures 1, 6, 7, 18, and 22 are photographs used by permission of Leupold & Stevens Instruments, Inc.