Maine Geologic Facts and Localities

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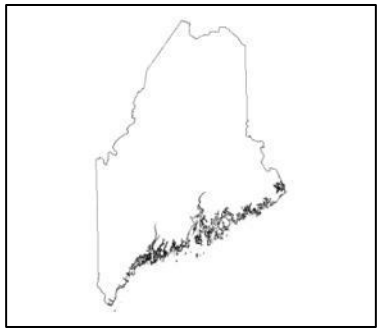
Measurement of Stream Discharge Using Weirs and Flumes



Text by
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Introduction

Hydrologists, hydrogeologists, engineers, biologists, foresters, and other natural resource professionals often evaluate stream or river flows at various times of the year to determine water budgets for drainage basins, aquatic habitat, and storm water runoff. Dam operators often measure flows from streams and rivers to evaluate water storage and determine how best to manage river flow and comply with regulatory requirements. Streamflow is typically measured using a variety of methods including current meters, moving boats, tracer dilution, weirs, and flumes. The focus of this narrative is to discuss the use of weirs and flumes in measuring streamflow.

In Maine, engineers and hydrologists routinely use weirs and flumes to evaluate flow in streams. The Maine Geological Survey (MGS) and U.S. Geological Survey (USGS) are actively involved in evaluating watersheds for water usage and availability. Typically, stream discharge is measured using current meters at selected locations within a basin. Monthly mean discharge is calculated and the results are used in three-dimensional ground water modeling. As streams follow their normal seasonal recessions, however, some stream measurement locations become either too shallow or water velocities slow to a point where conventional current meter measurements become unreliable. During these low flow periods, nearly all of the stream recharge comes from ground water discharge and the stream is said to be at baseflow conditions.

Flumes

When current meter methods can no longer be used, MGS hydrogeologists measure discharge using a flume, a device which constricts the width of the stream and causes the water level to change. The height of water measured in a specified position within the flume allows the user to determine flow through the device. MGS uses a USGS Three-inch Modified Parshall flume (Figures 1-3).

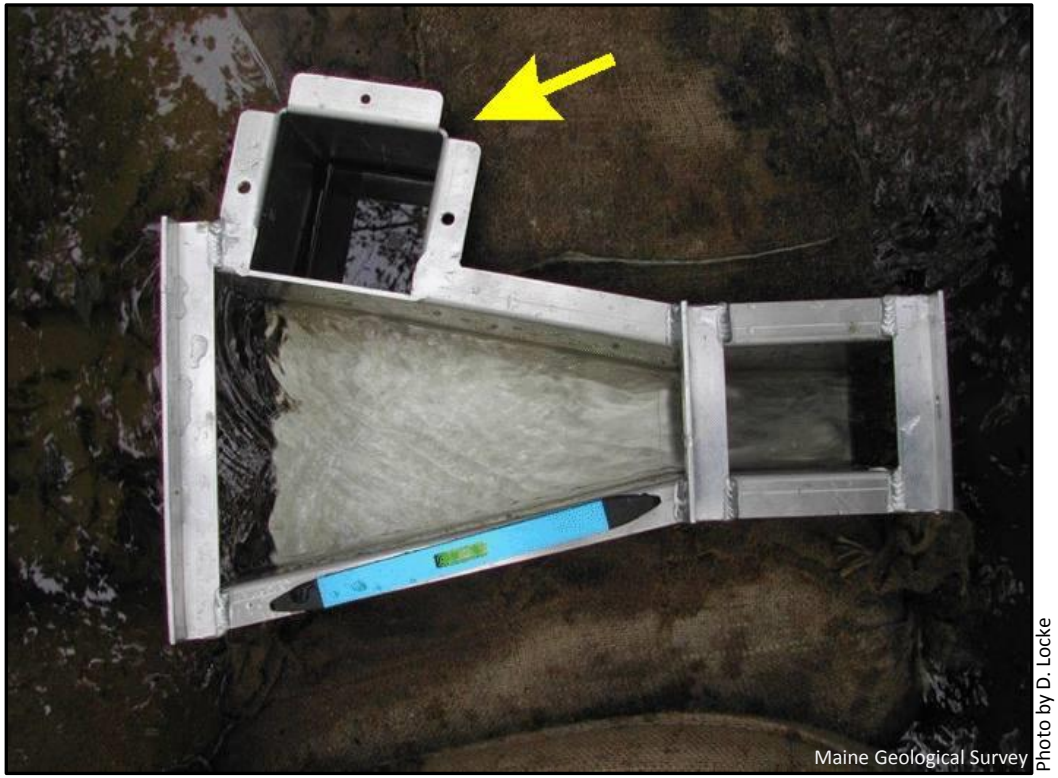

Figure 1. Top view of USGS 3-inch Modified Parshall flume with torpedo level. Note the stilling well where stage level is measured.

Flumes

Figure 2. View looking upstream at USGS 3-inch Modified Parshall flume with torpedo level across width. When installing a flume, the unit must be level along the length as well as the width.

Flumes

Photos by D. Locke

Figure 3. Views of the USGS 3-inch Modified Parshall flume. Note extensive sandbagging to prevent/minimize leakage. (Left) Looking upstream. (Right) Looking downstream.

Flumes

This flume is identical to the standard Parshall flume (Figure 4) except that the downstream diverging section has been removed to allow for greater portability and ease in installation. While this flume is capable of measuring flows up to nearly 0.5 cubic feet per second (cfs), MGS typically starts using it when flows decline to about 0.35 cfs or less.

Photo courtesy of the Colorado State University Water Resources Archive.

Figure 4. Dr. Ralph Leroy Parshall and the Parshall flume, 1946.

Weirs

Weirs are simply tiny dams with a spillway through which stream water discharges (Figures 5-7). By measuring the height of the water behind the weir relative to the elevation of the bottom of the spillway, engineers and hydrologists can calculate stream flow using published tables for specific weirs or the actual flow equations.

Figure 5. View upstream of 90-degree v-notch weir. Note splash plate downstream to prevent scour. The weir plate is installed by driving it into the stream sediment. For accurate measurement, it is absolutely essential that no or very minimal leakage occurs around the weir.

Weirs

Figure 6. View looking downstream at 90 degree v-notch weir. Note location of pipe stilling well used for determination of upstream stage for flow correlation. Stream flow is calculated using water level measurements taken in the stilling well.

Weirs

Figure 7. View looking downstream at 90 degree v-notch weir. Note location of staff gauge used for determination of upstream stage for flow correlation.

Using Flumes and Weirs

If conditions exist where low flows can be measured by volume, this method should be selected over all other methods as this is the most accurate way to measure discharge. However, if the flow cannot be measured by volume, a weir or flume may be installed. Weirs and flumes are used when measurement frequency demands render current meter measurements less viable or when flows are very low or the stream depth is very shallow. With both the weir and flume, water height or stage is related to flow through the device by unique mathematical equations. Compared to weirs, flumes have the advantage of less head loss and there are no dead zones where sediment or leaves and sticks can collect.

Much is written about flumes and weirs. Presently, there are several types of popular flumes including the Palmer-Bowlus, Trapezoidal, HS/H/HL-Type, Cutthroat, RBC, Montana, SANIIRI and many other custom designed flumes. Software has been written to aid in designing optimal flume types for specific applications and various computer assisted calculations are available for evaluating the various stage-discharge relationships.

References and Additional Information

Weirs and Flumes
Open Channel Flow Measurement 1: Introduction to the Weir and Flume

Parshall Flume
What is a Parshall Flume and who invented it?
ASABE Engineering Landmark No. 19 - the Parshall Flume (video)
Download CAD drawings of the Parshall Flume at the Colorado NRCS CADD Drawings website

Weirs
The Flow on the Sharp-Crested Rectangular Weir computer simulation

Stream Discharge Measurement
Discharge measurements at gaging stations
Measurement and computation of streamflow
Measuring discharge with acoustic Doppler current profilers from a moving boat
Water Measurement Manual