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# Design and Modification of an Installation Method to Stabilize Small Trapezoidal Flumes in Drainage Ditches

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**Abstract**

We developed procedures for installing prefabricated trapezoidal flumes in deep (10 to 12 feet) drainage ditches to monitor hydrologic functions and provide gauge locations for sampling discharge. Flows from the instrumented basins were generally low, but the ditches were occasionally subject to high flows caused by rain events of 2 to 3 inches or more. These high flow events caused severe erosion and undercut the flumes when they were installed in the usual manner, washing two of the flumes downstream. Our modifications to the installation procedure included four main elements: (1) securing the flume to a concrete pad; (2) bolting entrenched wooden barriers to the flume's inlet and outlet; (3) placing a plastic apron beneath the flume's outflow opening; and (4) surrounding the flume with sandbags. Flumes installed using these elements have been significantly more stable and resistant to undercut and bank erosion than those we installed using the normal methods. As a result, the modified installation procedures have reduced necessary maintenance and data loss, making the additional cost and increased initial effort well worthwhile.

## Introduction

Precalibrated flumes have been used for decades as control structures for measuring water flow in streams and drainage ditches (Brakensiek and others 1979). Such flumes are particularly convenient because the relationship of water level to flow volume (flow rating curve) is known. They also allow very accurate measurement, as well as easy access.

The trapezoidal flume was developed to measure a wide range of flows in irrigation channels and has been especially accurate in measuring low flows (fig. 1). The trapezoidal shape conforms to channel shape, and the straight bottom permits self-cleaning, thus reducing silt build-up.

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Flumes are chosen to accommodate a full range of drainage flows. Although time and money constraints may not allow it, runoff should be measured at low, medium, and high stages before installation. Our objective was to place prefabricated flumes in deep (10 to 12 feet), existing drainage ditches to monitor hydrologic functions and provide gauge locations for sampling drainage flow. Generally, flows were low where we installed our flumes, but the ditches were subject to occasional high flows caused by rain events of 2 to 3 inches or more.

Because of difficulties encountered in stabilizing the structures as well as in anticipating the effects of erosion, flume installation is not easy. Modifications we made to commonly used installation procedures, which resulted in the successful placement of this valuable hydrological tool, are described in this paper.

## Project Background

In May 1997 we installed three extra large, 60$^{o}$ V trapezoidal flumes, which were designed to handle flows from 0.0001 to 1.55 cubic feet per second, and one 2-inch, 45$^{o}$ WSC (Washington State College) trapezoidal flume, which was

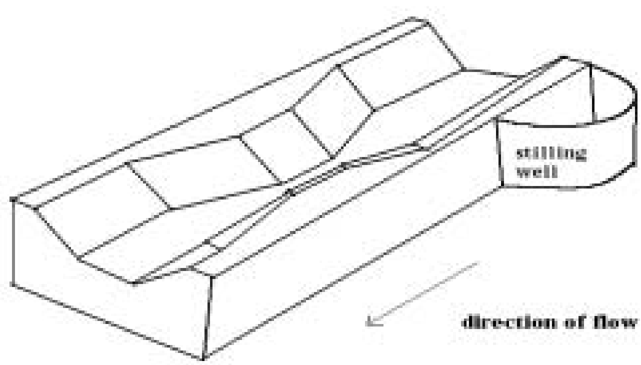


Figure 1—Typical trapezoidal flume.

designed to handle flows from 0.029 to 2.59 cubic feet per second. Both were constructed of fiberglass-reinforced polyester (FRP) and manufactured by Plasti-Fab, Inc. of Tualatin, Oregon. Temporarily interrupting stream flow, we placed and leveled the flumes in the channel beds. To direct and confine water flow, we used wooden posts and planks that were sealed to the flume with caulking. We packed native soil around the base and sides of the flumes, which also served to stabilize the structure.

That summer, two large rainfall events (2.89 inches on June 5 and 2.88 inches on June 27) caused excessive flows that undercut the flumes. Severe erosion occurred around the sides and base, and two of the flumes washed downstream. We modified the installation procedure in order to stabilize the structures. Our modifications have been successful, and, with minimal maintenance, the installations have survived numerous intense rain events.

**Modified Installation Method**

Modified flume installation was completed in October 1997. The tools and materials required for installation of a single flume are listed in table 1.

Our modifications included four major components:

1. Securing the flume to a concrete pad.

Using 2- by 4-inch lumber, we designed and constructed a concrete form about 3 inches shorter than the flume but wide enough to overlap its upper surface. We lined the form with felt paper and poured premixed concrete to a depth of 3.5 inches. After pouring about half of it, we embedded a strip of “hog wire” fencing (cut to fit within the form) to reinforce the finished pad. While it was still wet, we inserted two 18-inch lengths of 5/16-inch threaded stainless steel rod 2 inches into the concrete, each about halfway along the

**Table 1—Tools and materials required for installation of a flume by the modified procedure**

| Item | Quantity | Comments |
|---|---|---|
| Flume | 1 | — |
| 5/16-inch threaded stainless steel rod, 18 inches long | 2 | — |
| Wooden form | 1 | Made from 2- by 4-inch boards; used in pouring concrete pad |
| Felt paper | 1 | Piece slightly larger than form dimensions |
| Hog wire | 1 | Piece slightly smaller than form dimensions |
| Quickrete concrete, 50-pound bag | 3–4 | — |
| Sandbag, 50 pound | 30–50 | — |
| Washer and nut | 6–8 | For securing flume to concrete pad and 2- by 8-inch boards to flume |
| Bolt | 4 | For securing 2- by 8-inch boards to flume |
| 2- by 8-inch board, 12 foot long | 2 | Use treated wood |
| Black plastic sheet, 6 mil | 3 | One approximately 3- by 6-foot piece, plus two pieces for use in covering sandbags |
| Chainsaw | 1 | — |
| Wheelbarrow | 1 | For use in mixing concrete |
| Shovel | Several | Recommend at least one “sharp-shooter” shovel, as well as a flat-bladed and normal blade shovel |
| Portable drill (with bits) | 1 | — |
| Level | 1 | — |
| Pencils/markers | Several | — |
| Carpet knife | 1 | — |
| Socket wrenches (and drivers) | Set | — |
| Grass seed | — | Planted on soil/plastic covering sides of flume |

length of the pad. We set one post approximately 1 inch from one edge of the form, the other about 2 inches from the opposite edge. We allowed the pad to cure for 24 to 48 hours before transporting it to the study site.

At the site, we selected an appropriate location in the ditch. Selection criteria included (a) a relatively stable, straight section of ditch; (b) a location sufficiently downstream to enable data collection; and (c) ease of access.

We used sandbags to temporarily block stream flow and excavated an area in the center of the ditch, including the thalweg, to allow for level placement of the concrete pad and installation of a stilling well. The stilling well is built onto the side of a flume to allow accurate measurement of water volume and provide a place to attach other sampling devices. We laid the pad and checked for level (fig. 2). Placing the flume directly over the pad, we marked it and drilled holes through which the threaded rods would pass. We fastened the flume to the pad with washers and nuts, checking for level several times in the process. After ensuring that the hole for the stilling well was sufficiently deep (so the flume rested level on the concrete pad), we secured the structure with another washer and nut.

2. Bolting entrenched wooden barriers to the flume's inlet and outlet.

We used sharp-shooter shovels to dig trenches directly in front of and behind the flume, extending approximately 1 to 1.5 feet into the ditch banks and 3 to 4 inches below the ditch bottom. We cut 12-foot lengths of 2- by 8-inch boards and set them into the trenches. We then sketched onto the boards the inflow and outflow openings and used a chainsaw to cut the openings. Anchoring the boards into the ditch banks added considerable stability to the structure.

3. Placing a plastic apron beneath the flume's outflow opening.

Before fitting boards into the trenches, we placed a 3- by 6-foot sheet of 6-mil black plastic under the outflow opening and across the adjacent trench to reduce chances that turbulence would undercut the rear of the flume during periods of high flow. We then positioned the sections of board (the rear board holding the apron in place) and drilled holes through both board and flume. After bolting the rear board to the flume, we trimmed excess plastic from the outflow opening and packed excess soil around board ends.

4. Surrounding the flume with sandbags.

We used 50-pound fiberglass sandbags to fill in around and stabilize the flume. We positioned one bag directly under the flume outflow—on top of the plastic apron—and arranged other bags at about a 45$^{o}$ angle to direct and confine water flow in front and back of the flume. We placed additional sandbags on both sides, level with the flume's upper surface.

We packed excavated soil between the sandbags to further stabilize the installation. The appearance of the flume after this stage is shown in figure 3.

Flume installation was complete. Additional equipment, such as stilling-well towers, water-level recorders, and automated water samplers, could now be attached or installed as needed.

## Discussion

Flumes installed using the modified procedure were significantly more stable and more resistant to undercut and bank erosion than those we installed earlier. Although the modified method costs more initially and is more labor-intensive, it has withstood the high-intensity, short-duration rain events common to the study site.

Figure 2—The concrete pad (showing embedded stainless steel rods) fitted into an excavated hole in the ditch bed. Incipient trenches for the 2- by 8-inch boards and a cavity for the stilling well of the flume are also visible.

Figure 3—View of completed installation. The notched 2- by 8-inch board bolted to the outflow opening, the plastic apron, and the sandbag emplacements are visible.

Approximately 8 months after installation, minor maintenance was necessary—mainly replacing torn or damaged sandbags. As a result of exposure to ultraviolet radiation, some of the fiberglass bags had deteriorated and were replaced. To reduce deterioration, we covered the bags with black plastic, covered them with soil, and planted a variety of hardy grasses. Although planting significantly reduced bag deterioration, concrete-filled sandbags may provide more stability and require less maintenance. After 4 years, installed flumes have sustained no significant damage, and it will be possible to remove them once the study is complete. They will be suitable for re-use at other locations.

## Summary

By making simple modifications to basic installation methods, we were able to use small trapezoidal flumes in deep ditches that experience brief but intense rainfall events. Increased stability and durability of the flumes has reduced necessary maintenance, as well as potential data loss, thus making the additional cost and effort well worthwhile.

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