An empirical V-notch weir equation and standard procedure to accurately estimate drainage discharge

Md Sami Bin Shokrana and Ehsan Ghane*

Department of Biosystems and Agricultural Engineering, Michigan State University, East Lansing, MI 48824, USA

*Corresponding author e-mail address: ghane@msu.edu

Article type: Research brief

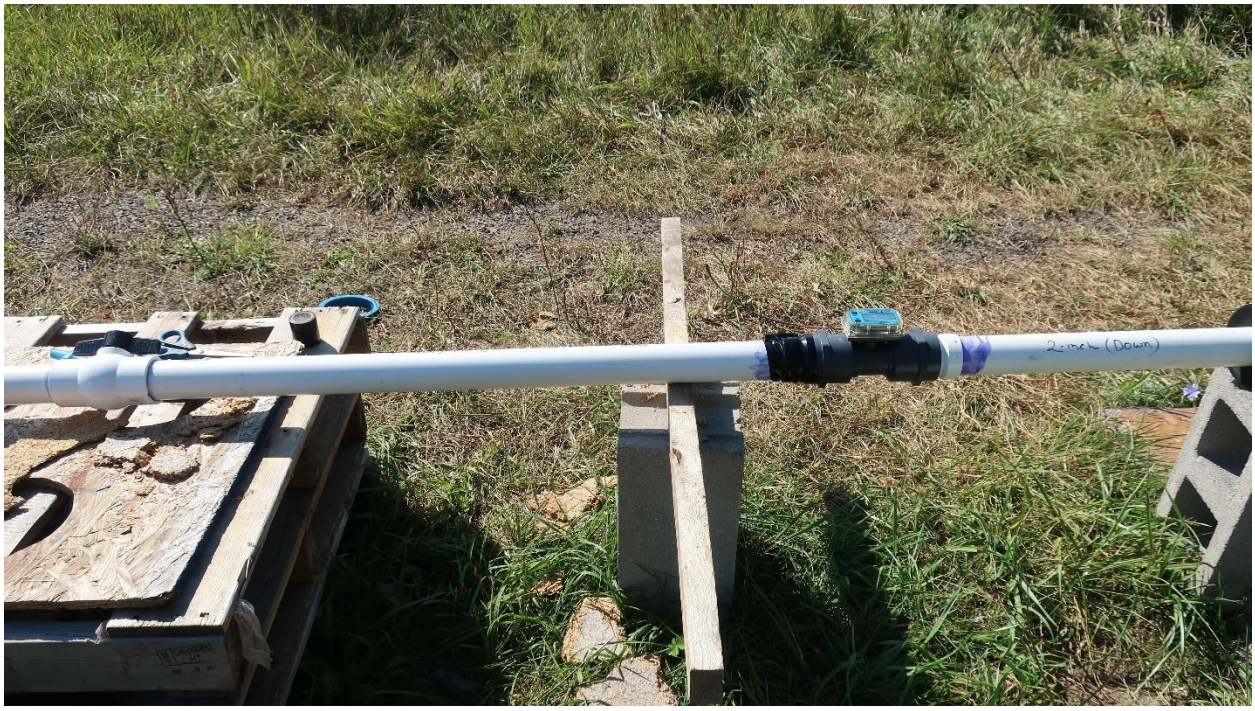
Applied Engineering in Agriculture

Supplementary Fig. S1

Pumping water from the pond using a flexible PVC pipe. A blue lay flat discharge hose was connected to the discharge side of the pump to convey water through the flow meter and the control structure. Finally, the pumped water flowed through the outlet of the control structure back to the pond.

We used a centrifugal pump (Pacer pumps, model number SEB2ULE51C) to collect water from the pond. A box quarter turn ball valve was used to regulate the flow rate.

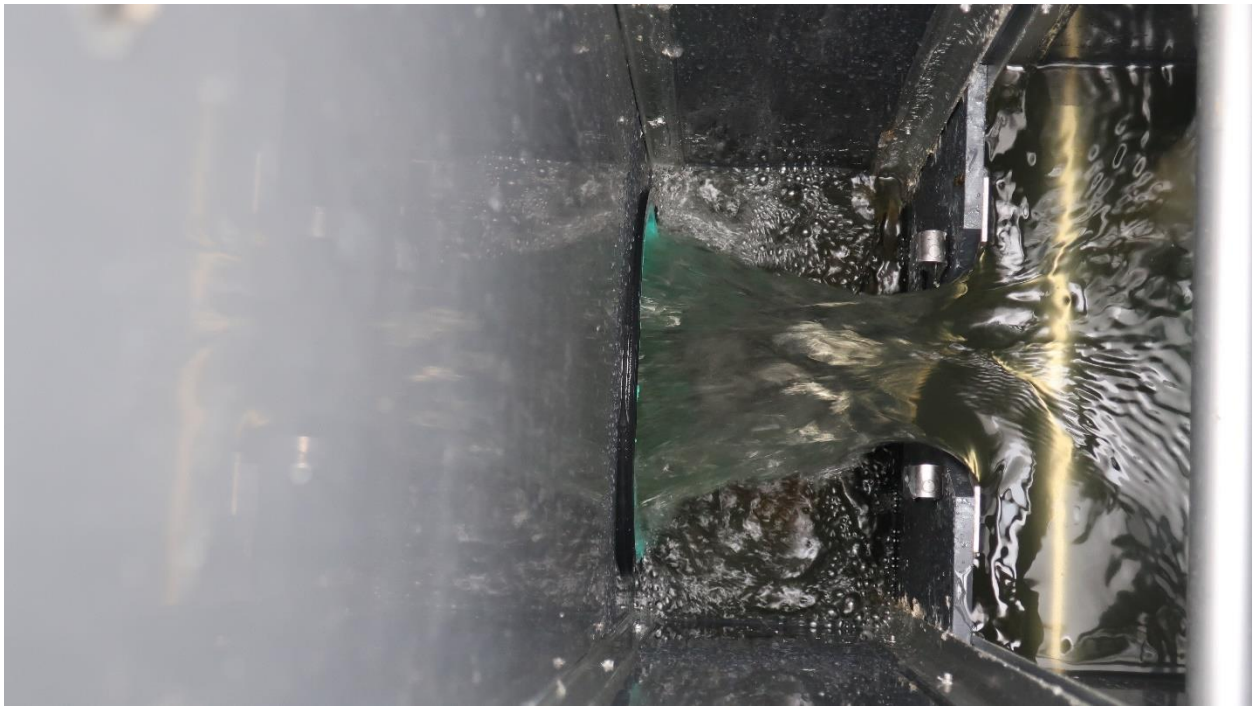
A 100-ft long lay flat discharge hose was used to convey water from the pond. The lay flat discharge hose was attached to a PVC pipe upstream of the flow meter. An additional ball valve was connected to the PVC pipe to adjust the flow rates as per the need of the experiment.



We maintained the optimum pipe length for the turbine flow meter. Based on the turbine flow meter manual, the upstream and downstream pipe lengths of the flow meter should be at least ten (10) times and five (5) times the diameter of the turbine (i.e., 5 cm), respectively. In our experiment, the upstream pipe length of the flow meter was 101.6 cm (20 times the turbine's diameter) and the downstream pipe length was 50.8 cm (10 times the turbine's diameter). The upstream and downstream pipes were level throughout the experiment.

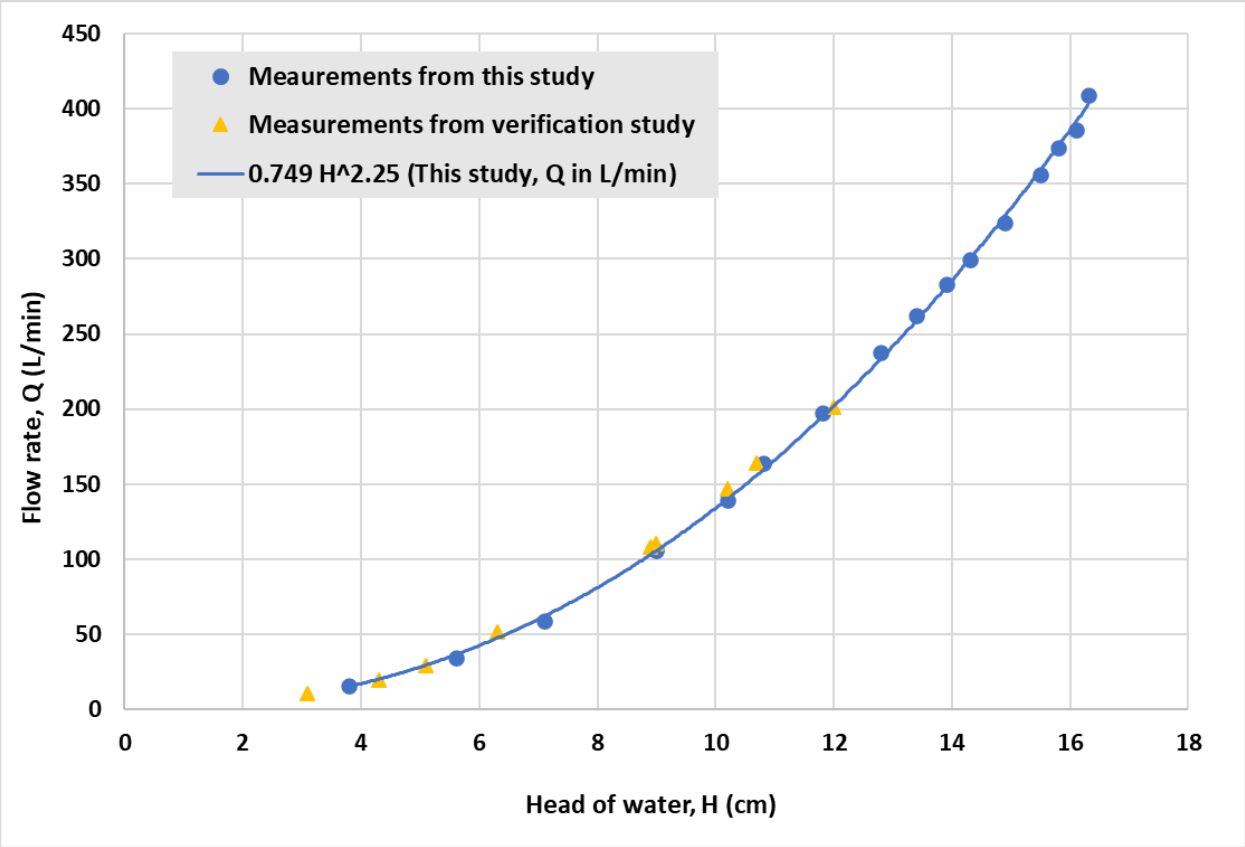
A reading from the turbine flow meter taken during a practice run of the experiment, hence not included in the experimental data.

The pumped water from the pond flowed through the flow meter, then to the control structure, where a metal-edge sharp-crest 45° V-notch weir was placed

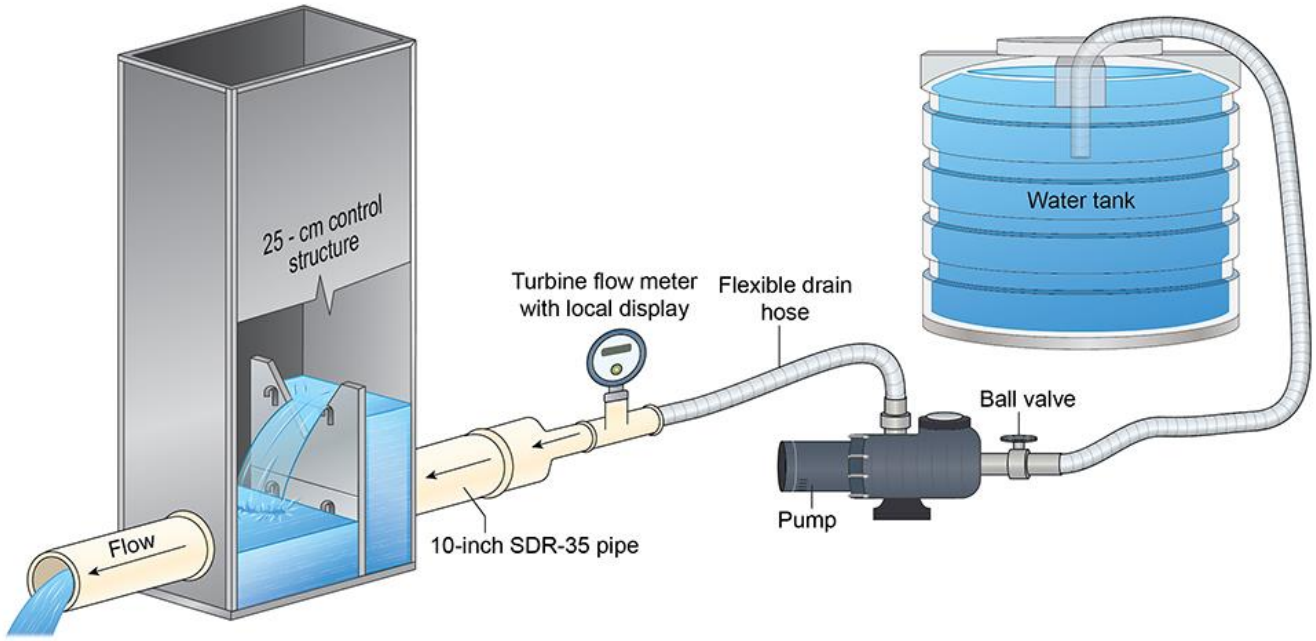


An image of water flowing through the metal-edge sharp-crest 45° V-notch weir

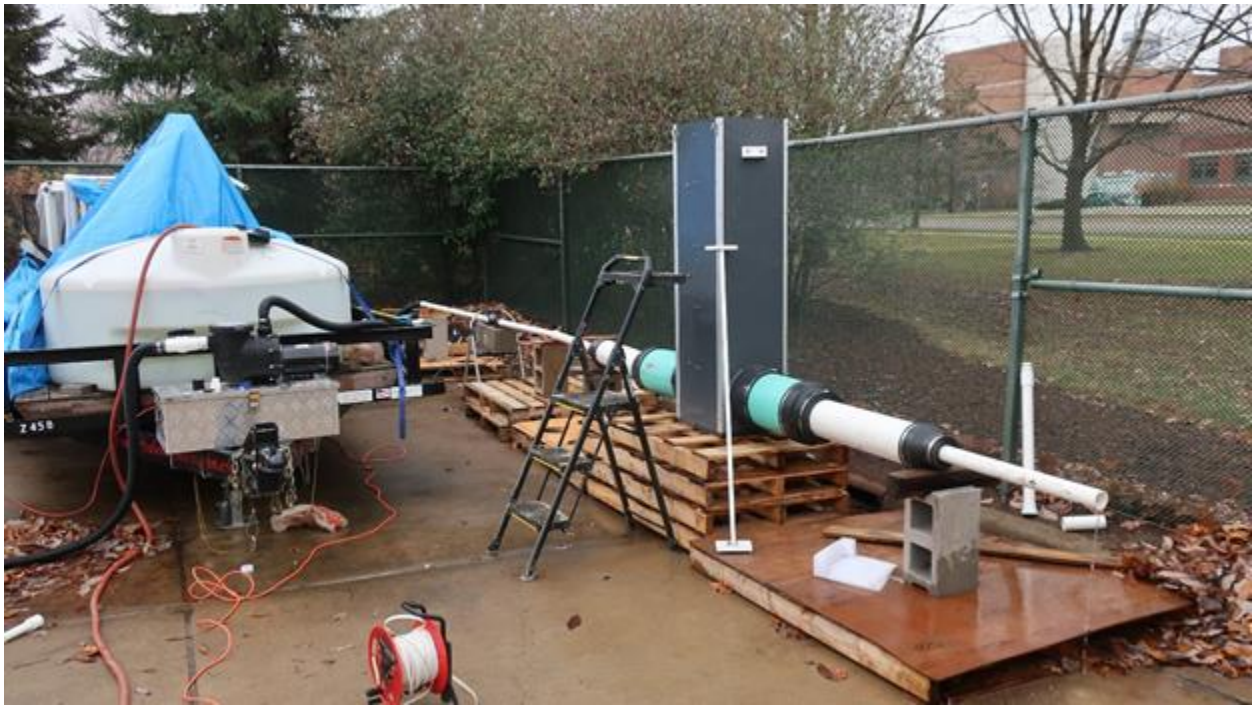
Supplementary Fig. S2



A combined plot of measurements obtained from this study and the verification study, each conducted under a different setting. The former was conducted using pond water and the latter was conducted using tank water. This graph proves that the flow meters were not overestimating compared to the weighing method.



A schematic diagram of the experimental setup of the verification study. A 300-gallon water tank was used instead of a pond during this experiment



An image of the experimental setup of the verification study conducted at Michigan State University

For the experiment conducted during this study (as mentioned in the manuscript), we used the combination of a weighing method and a flow meter (Flomec GPI turbine flow meter, model number TM20NQ9GMB) to estimate flow rates. This flow meter was factory calibrated and had a flow measurement range of 75-757 L/min (20-200 gallons/min, with a ±3% accuracy). We pumped (Pacer pumps, model number SEB2ULE51C) water from a pond and water was conveyed to the control structure using a blue lay flat discharge hose. For this experiment, the developed flow equation is valid up to a head of 16.3 cm.

This study showed that (fig. 6 in the manuscript) the flow rates predicted by our equation were higher than those developed by Christianson et al. (2019) for almost all the measurements. We verified our equation with a previous experiment (i.e., verification experiment) conducted with a different setting.

For this verification experiment, we used two turbine flow meters from OMEGA Engineering (FTB693A-NPT and FTB694A-NPT-P) with a flow measurement range of 7-70 L/min (2-20 gallons/min) and 37-378 L/min (10-100 gallons/min), respectively. For the lower flow rates (7-70 L/min), we used the FTB693A-NPT flow meter, and for the higher flow rates (37-378 L/min), we used the FTB694A-NPT-P flow meter. In the verification experiment, we pumped water out of a 300-gallon tank instead of a pond. A flexible drain hose (Sump pump discharge hose, Star Water Systems) was used to supply water to the flow meter and to the control structure. For this verification experiment, we verified the readings of both turbine flow meters with a weighing method. Once the water started flowing through the V-notch weir, we held a 5-gallon bucket at the outlet of the control structure, recorded the time required to collect a specific volume of water in the bucket, weighed the bucket (weighing scale model: Brecknell PS-USB portable scale), and calculated the flow rate. We took three weight readings (triplicate readings) for each turbine flow rate reading and compared the average flow rate from the weighing method with the reading from the turbine flow meter. The quality control measures for this verification experiment were the same as those adopted for the study mentioned in the manuscript. For the verification experiment, the developed flow equation is valid for a head of 12 cm.

Although both studies were conducted in different settings, supplementary fig. S2 showed that the measured flow rates were in close agreement with the measurements in the current manuscript. All the measurements from the verification study were measured by flow meters. Those readings from the flow meter closely followed the same regression line developed from the measurements of this study as mentioned in the manuscript. The first three measurements from both studies (blue circles and yellow triangles) were in close agreement. This proved that our flow meters were not overestimating compared to the weighing method.