In-Situ Inc.

Innovations in Water Monitoring

Technical Note

Using Data Loggers to Measure Flow in Open Channels

November 2014

Introduction

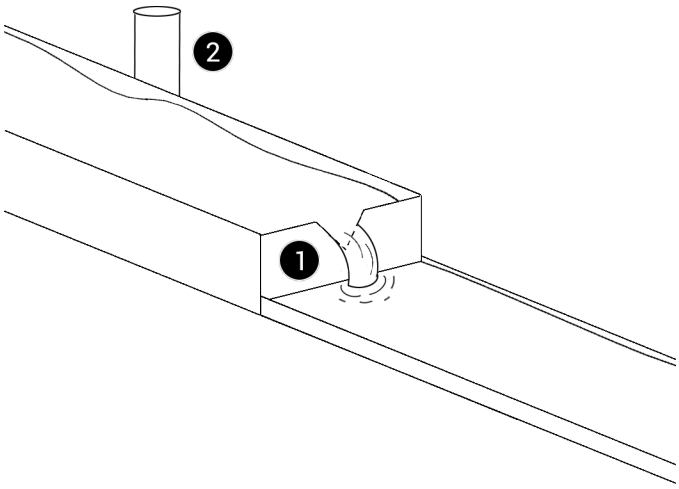
Open channel flow exists whenever liquids flow with a free surface. Examples of open flow are rivers and irrigation channels, but enclosed channels (e.g., storm sewers) may be included when partially full and not under pressure.

Hydraulic structures are a common and useful method for measuring open channel flow. In most cases, a calibrated restriction is placed in the channel to control the shape and velocity of the flow at a specific location. The flow rate is calculated by recording the fluid level at or near the calibrated restriction point.

Two primary types of hydraulic structures are flumes and weirs. Each has advantages and disadvantages.

Weirs

The advantage of a weir is that it is simple and inexpensive to install. An obstruction is placed in an open channel which impounds a portion of water behind it. This obstruction can be made of wood, plastic, metal, or other materials. The water level rises and eventually exits through an opening in the weir. The shape of this opening is important as it relates to how fluid flows are calculated across the weir. The v-notch weir has a triangular opening and is the most common for low discharges. Rectangular and trapezoidal openings are also used. Flow rates are calculated by measuring the depth of liquid in the pool upstream of the weir.

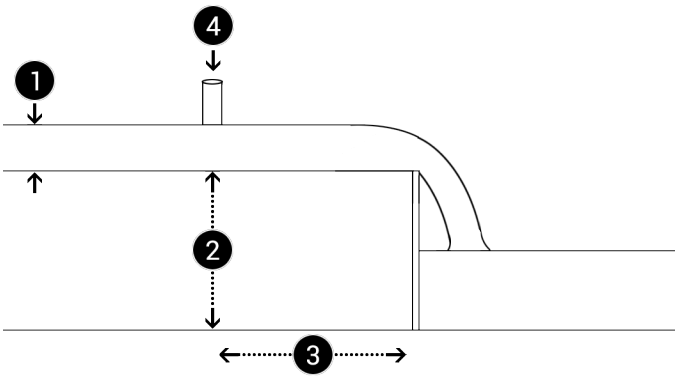


1	Triangular weir
2	Standpipe for calculating depth

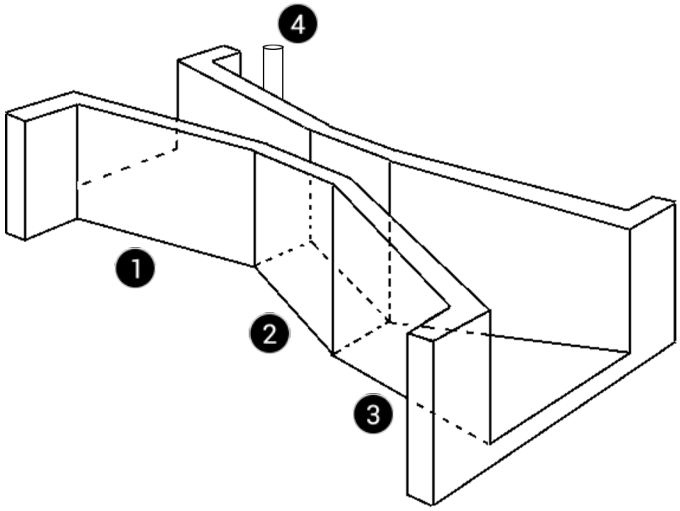
A major disadvantage of the weir design is that a significant loss of head is usually observed. In effect, the weir creates a small dam in the channel which can accumulate solids (sediment and/or debris) behind it. Since accumulated solids will affect water depth behind the weir and therefore disrupt flow calculations, weirs have a high maintenance requirement. Even with regular maintenance, weirs may still be considered unsuitable when measuring flows when solids are present (i.e. most naturally occurring channels).

There are a few standards to follow when measuring flow using a weir. For a v-notch weir, the angle of the opening should be precisely 90 degrees. In addition,

the point of level measurement should be upstream from the weir at a distance of least four times the distance from the bottom of the weir opening to the maximum head above the weir.



1	Maximum head (Hmax)
2	2-3 Hmax minimum
3	3-5 Hmax minimum
4	Point of measurement



1	Converging section
2	Throat section
3	Diverging section
4	Point of measurement

Flumes

Flumes are more complex hydraulic structures, but have significant advantages over weirs. Instead of restricting channel flow at a single point, flumes replace an entire section of the channel. Flumes provide a restriction in channel area and may include a change in channel slope as well. Water is only restricted ("squeezed"), not impounded, so head loss is minimized and the structures are effectually self-cleaning. The shape and dimensions of the flume are fixed with known measurements. Therefore, a flume is designed to measure open channel flow by taking level measurements at a specified point within the structure.

The Parshall flume is most common and calculates flow rates by taking level measurements at a specified point one-third of the way into the converging section. Flow calculations are determined by the width of the throat of the flume, which can range from one inch to 50 feet. All corresponding dimensions must be strictly followed so that standardized discharge tables can be used.

Due to their highly engineered and precise specifications, flumes are more expensive to build. Installation is also more time consuming and expensive, as the flume is effectively replacing a portion of the open channel. Pipe applications, where a structure can be placed according to the pipe dimensions, are typically not as expensive.

Submerged Flow

Submerged flow is an important concern for both weir and flume applications. Flow calculations are most easily determined with a single level measurement in non-submerged conditions.These calculations become more complex in submerged conditions, as they require that both upstream and downstream levels are measured, and that data from submerged flow tables be incorporated. Thus, both weir and flume structures should be installed so that downstream conditions do not affect flow rates through the structure. Using a v-notch weir example, the distance between the bottom of the notch and the pool surface below the weir must be

at least .05 meters to insure that submerged flow conditions do not exist.

Data Loggers

While many tools are available to measure liquid levels, In-Situ Level TROLL Data Loggers provide rugged, accurate, and consistent measurements while recording level data over time. Level TROLLs log data on a user-specified schedule and are accurate to .01 feet. Once level measurements have been made, flow rates are determined based on the known rate of flow at a given level. If a level-to-flow rate relationship has not been established for a particular structure, it can be easily calculated using an open channel flowmeter.