Ryan Thorpe
Flow Visualization
Group Project 1

Flume Photographs

The flume was chosen because we assumed that we could come up with some very interesting photos with little effort. We were wrong. In all actuality good shots were not only hard to take but hard to produce. From the out start we were not 100% sure of what we were looking for but we were hoping to get some great turbulence photos with dye. There were a couple of obstacles that we hoped would give interesting turbulence effects but the only one that did was the double hump obstacle, see figure 1.

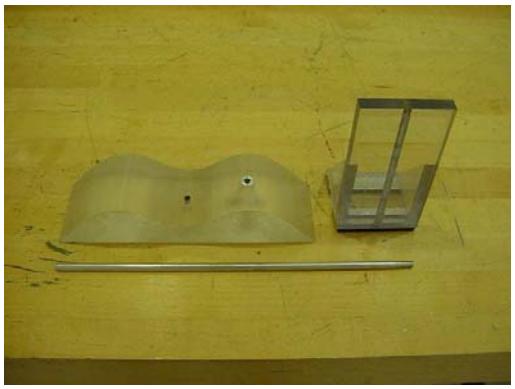


Figure 1. Left item is the double hump weir; right is the vertical wall weir.
The small holes in both weirs allows for dye to be injected out into the flowing water.

The double hump weir was able to create very interesting flow structures between its two ridges. Below is diagram of how the flow was set up. Turbulent eddies are illustrated between the weir peaks to illustrate how dye would move if it were inside the flowing water, see figure 2.

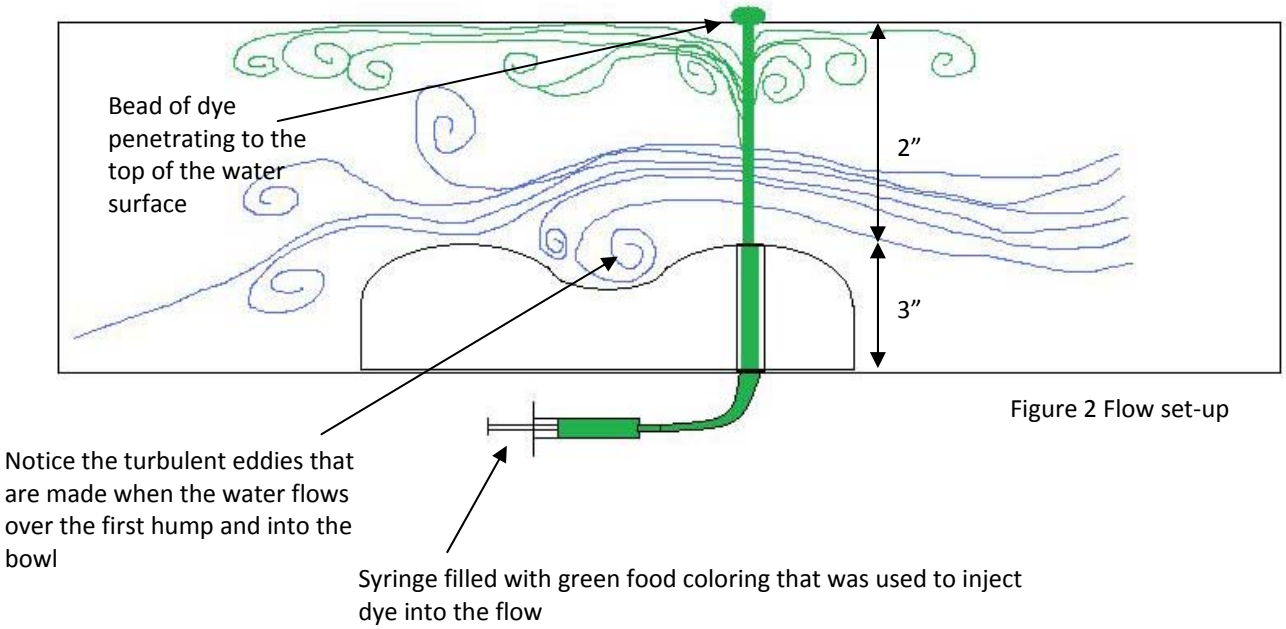


Figure 2 Flow set-up

The uniqueness of the photo comes from the fact that multiple flow structures are happening at once. For instance there is not only fluid impingement with the dye barely piercing the top of the water's surface but there is also plenty of turbulence between the two weir humps. Regarding the first, it is interesting to see that enough initial velocity was imparted to the dye to actually make it travel all the way up through the moving water while keeping a relatively straight path. That was no easy feat since the water was estimated to be flowing at approximately 0.5 ft/sec. The following calculations show how initial velocity was estimated, where h =2 inches. Changes in potential energy are neglected because of the small height differences, P_2 is assumed to atmospheric and u_2 is assumed to be zero.

$$\frac{1}{2}u_1^2 + \frac{P_1}{\rho} + gz_1 = \frac{1}{2}u_2^2 + \frac{P_2}{\rho} + gz_2$$

$$\frac{1}{2}u_1^2 = -\frac{P_1}{\rho}$$

$$u_1 \approx \sqrt{\frac{\rho g h}{\rho}}$$

$$u_1 \approx \sqrt{gh}$$

$$u_1 \approx 2.81\ \frac{ft}{sec}$$

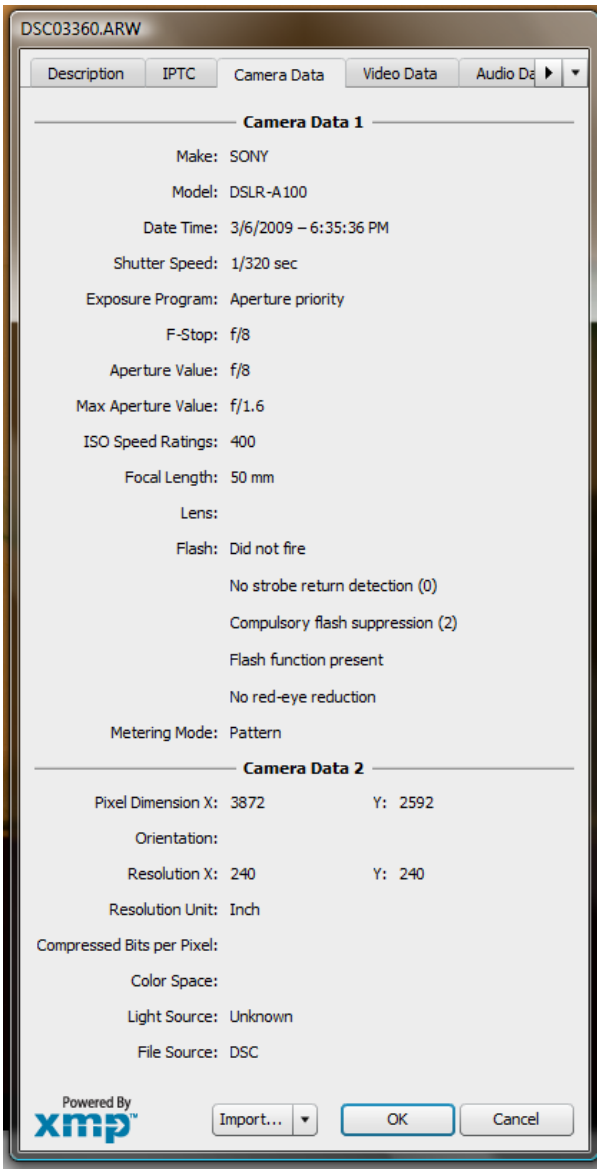
Although 2.31 ft/sec is a high estimate for the initial velocity of a moving fluid it should be expected that the initial velocity will need to be somewhat high if the jet of dye is to impinge the water's surface.

The next topic deals with the turbulence between the humps of the weir. Figure 2 shows how the water flows over the hump of the weir and starts to sink down due to gravity and then makes contact with the second weir. The term contact is used to describe the flow structures contact with the right sop of the second hump. This contact causes the flow structure to flow back into itself causing. Another way of looking at the mechanism that caused the eddies is think about it as "recirculation". When the stream of water flows over the first hump is imparts some of its momentum to the water in the bowl between the humps. That momentum causes that packet of water to spin in the bowl in such a way that the momentum it is given by the above fluid is used to create recirculation flow structure. That sort of recirculation is an indication of turbulence in the flow. The flow was deemed turbulent because of its Reynolds number, with density (ρ), mean velocity (u), flow depth (D) and viscosity (μ).

$$Re = \frac{\rho u D}{\mu}$$

$$Re = \frac{\left(62.3\ \frac{lb}{ft^3}\right)\left(0.5\ \frac{ft}{sec}\right)(0.166\ ft)\left(\frac{1}{g}\right)}{\left(2.344E-5\ lb\frac{s}{ft^2}\right)} = 6905$$

On the photographic aspect there are had to be special lighting to get decent photos. Since the ambient light in the ITLL was not bright enough to clearly discern a good contrast between the dye and the water a pair of flood lights were used to provide ample lighting. However there was glare on some photos and different shot angles were uses to avoid it. A white back drop was also used to bring out the contrast of the green dye and the water. For a good shot that displayed all the flow structure a 6" x 14" field of view was used. To keep the shot as focused as possible I stood about 1.5 ft away from the flume, (the minimum the camera could do while remaining in focus). Below are the Photos specifications.



The facet I like most about this photograph is that there are more than one flow structures existing in the same frame. This sort of contrast really brings out the physics between the two and also shows how they are related. I also like the image because it resembles a crane, much like the one looming over the new arts building construction site on the west side of the CU campus.