

Stefan Schultz

Flow Visualization

**Project 1: Get Wet**



The objective of this first image was to investigate any of the myriad of visible fluid dynamics that we could create. Initially it was my intent to photograph a visualization of a turbulent jet. For multiple images, ink, dyes and even fake blood were shot into a large tank of water using a syringe. However, none of these images were what I had envisioned and ended up being a bit bland. The image taken and presented for criticism happened as a stroke of luck on a hike. The small stream shown was found in a small canyon as it flowed its way into a larger reservoir about a mile downstream. Here, it was my intent to highlight the bubbles generated from the turbulent flow of the water from a small waterfall just before the location where the image was shot.

In this case, as an image of a natural flow, no apparatus or experimental setup was used. It is an image of a small mountain stream in Forsythe Canyon about one mile west of the west edge of Gross Reservoir. The stream itself was approximately 3ft. in width traveling about 0.5 ft/sec on either side of the waterfall. The waterfall itself was about 1ft. long and at a shallow angle near 30 degrees with the water flowing at about 2ft/sec down its slope. For this situation:

$$Re = \frac{0.61 \frac{m}{sec} (0.3 m)}{1.004 \times 10^{-6} \frac{m^2}{sec}} = 182,271$$

Meaning the flow at the end of the fall is undoubtedly turbulent. The flow from the waterfall caused a small cavity as it enters the water downstream allowing air into the water and creating the bubbles shown, as well as turbulence near the base of the waterfall. Although it cannot be explicitly seen in the image, the pinecones were actually trapped in a small vortex that kept them from moving downstream as I shot the images. The clumping of the bubble seen in the image is a result of surface tension, specifically a property called the Cheerio effect. On the surface of a fluid an object will seek the highest point and will thus move to the center or edges. In this case a single bubble will locally raise the fluid surface and other bubbles will gather near the first one. The cluster raises the surface more and will attract more bubbles as it travels. This property can be observed with breakfast cereal in milk as well, hence the name of the property.

This image was produced using the very clear mountain stream water that was flowing through the canyon. The image was taken in early September in the early evening near 6 PM. All light was from natural sunlight on a partly cloudy day, nearly aligned with the direction of the canyon ( $\pm 5$  degrees), so that none of the light was directly blocked by the walls of the canyon. There was some diffusion and blockage of light through the nearby trees.

The image was captured on a Nikon D90 camera with a standard lens, from a distance of about 4in. from the pinecones in the stream. The image captures a frame of about a foot width and about an 8in height. The shutter speed of the image was 1/200 sec. Since the stream was flowing slowly this was sufficient to minimize the blur from its movement. Also, the pinecones acting as the focus were moving relatively little since they were caught in a small eddy generated by the flow. An aperture of F8 was used to allow for a larger amount of light to enter the camera as the area of the image was slightly shaded by the surrounding trees, as well as to compensate for a relatively quick shutter speed. The ISO used was

3800 and the focal length of the image was 48 mm. These parameters combined allowed for a clear macro image of the pinecones floating in the stream. The focus of the image was all manual. The pinecones were used as a focal subject to make it easier to create a clear focused image. The bubbles and the rest of the stream were continually moving and made focusing on one spot nearly impossible. Whereas the pinecones, being trapped in place were much easier to focus on. Photoshop was used in the post processing of the image. The curves tool was used to enhance the white color along the edges of the bubbles and improve the contrast between the colors of the water and those of the pinecones. An unsharp mask was also used to improve the sharpness of some minor fuzzy areas around the bubble clusters in the image.

The image reveals some dynamics that we typically take for granted. All of us have walked by a stream or river and have seen waterfalls of varying sizes, but no one really considers what is actually happening in the flow and instead simply accept that it's just a river and continue with their lives. I really enjoy the gentle nature of the image, as opposed to the more aggressive flows of the turbulent jets I had tried to capture before. Although not a conscious decision, I also like how the bubble have very clear reflections of the surrounding woods and sky. The image does a good job capturing some of the physics of bubbles. However, it does not capture the dynamics of how the bubbles were formed, at least not without some of the background on the location of the image. It also doesn't really show that the pinecones were trapped in a small vortex in the stream and were not moving downstream at the moment of the image. To take this image further I think separating it into separate images that showcase a singular phenomenon could be interesting. It could be split up into an image of just one of the bubble clusters around the pinecones, an image of just one large bubble with the background clearly reflected in the surface, or an image of only the pinecones with the bubble streams moving through them. In this case I would like to present all of the images together, all of the little pieces as well as the whole, to showcase each dynamic piece and how they come together to form the entire flow in the current image.