Get Wet Report
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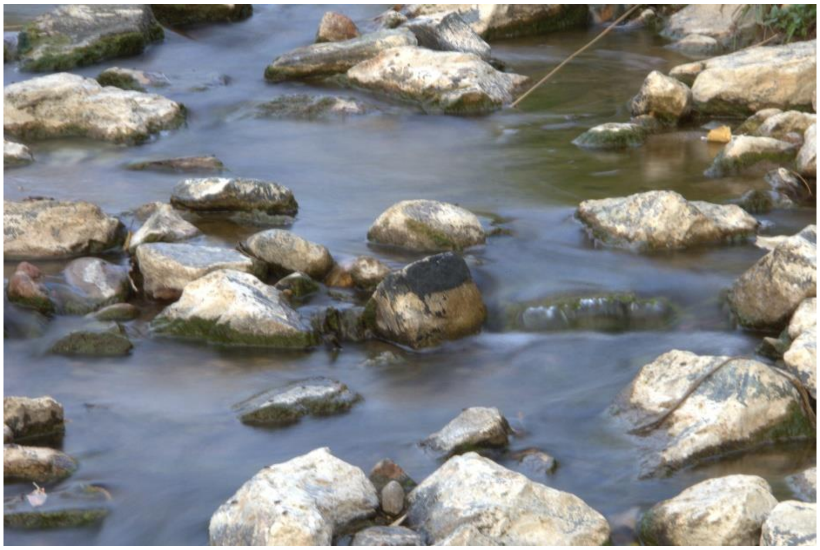

Original unedited photo

This image was captured as part of a project for a Flow Visualization course, where the goal was to study and document fluid motion and flow as well as produce a visually aesthetic photo. Specifically, I focused on the flow of water in a natural stream, attempting to capture its movement and the interactions with surrounding elements. I attempted to capture a location on the stream that contained a bit of everything such as fast- and slow-moving water, smooth and rough water surface appearance, and even a small waterfall. During the process, I encountered several challenges in capturing the right balance of motion and clarity, but the final image, after a little editing, represents my successful attempt at freezing the dynamic qualities of the stream in a still frame.

The stream in the image is a natural waterway located in Highlands Ranch, Colorado, with no artificial setup. It spans approximately 8 feet in width, with a depth ranging from 1 inch to 6 inches. However, my focus is on a 12-inch-wide section. The water flow is governed by fluid dynamics principles, including gravity, friction, and continuity. Gravity drives the water downhill, with steeper slopes leading to faster flow. The streambed's shape influences the water's velocity: smooth, deep channels reduce friction, allowing quicker movement, while rocky or shallow areas slow it down. The principle of continuity ensures the volume of water remains balanced throughout the flow. Turbulence, including swirls and eddies, can develop in faster-moving sections due to obstacles and uneven surfaces, which shape the stream's movement. In this image, the water flows over submerged rocks and uneven terrain, creating small eddies and turbulent patterns typical of shallow streams. A sketch of the stream's features, including rock placement and channel width, is provided below (Figure 1). The red line marks the direction and path of the fluid flow captured. The purple box highlights a section with a slow, laminar-like flow and a smooth surface. While not perfect laminar flow, it appears laminar due to the lack of obstructions. This smoother section, where water flows over relatively flat, unobstructed surfaces, exhibits parallel layers of water moving with minimal mixing, resulting in low-friction, consistent motion (Figure 2a).[1] Using the equation for Reynolds number, I was able to estimate the flows characteristics as follows:

$$Re = \frac{\rho v D}{\mu} = \frac{(1000\frac{kg}{m^3})(0.3\frac{m}{s})(0.0762m)}{0.001pa} = 22{,}860$$

I obtained the velocity using a fluid flow detector and estimated the depth of the stream. Surprisingly, the flow is turbulent, however, when in a setting like this where you can easily compare the visual aspects of the stream at different points, it looks like laminar flow. At this point, I calculated that the stream moved 0.6m during the 2 second shutter speed.:

$$Distance = V\ x\ T = 0.3\frac{m}{s} * 2\sec = 0.6m$$

The blue box shows the opposite observable type of flow, turbulent, due to lots of obstruction including the rocks on either side as well as a bunch of smaller rocks on the riverbed underneath like the phenomenon observed in (Figure 2b). This sections Reynold's number can be estimated as follows:

$$Re = \frac{\rho v D}{\mu} = \frac{(1000\frac{kg}{m^3})(0.5\frac{m}{s})(0.0508m)}{0.001pa} = 25{,}400$$

Unsurprisingly, the flow highlighted by the blue box is even more turbulent than the purple box. The distance the water moved in this region of the stream is calculated to be 1m following a similar calculation as the one above with velocity being 0.5m/s. The green box highlights a small waterfall wherein you can observe the water flowing over the edge, creating an air pocket on the face of the waterfall ledge. Bernoulli's principle explains how the water stream narrows and speeds up as it falls, resulting in a decrease in pressure at the edge of the ledge due to the increased velocity of the water flow.[2] Using simple kinematic equations, one can calculate the velocity of the water flow as it flows over the ledge.

$$v = \sqrt{2gh} = \sqrt{2\ x\ 9.81\frac{m}{s^2}\ \ x\ 0.127m} = 1.58\frac{m}{s}$$

This drastic change in speed due to the free fall of water can be observed in the form of, comparatively, more disturbances in the waterfall base. These visible flow patterns reveal the complexities of natural water motion, especially in shallow areas where the boundary layer effects are significant.

[1] Yokosi, S. (1967). The structure of river turbulence. *Bulletin of the Disaster Prevention Research Institute*, *17*(2), 1-29.

[2] McLean, E. P. (2023). *Nonlinear free-surface flows, waterfalls and related free-boundary problems* (Doctoral dissertation, UCL (University College London)).

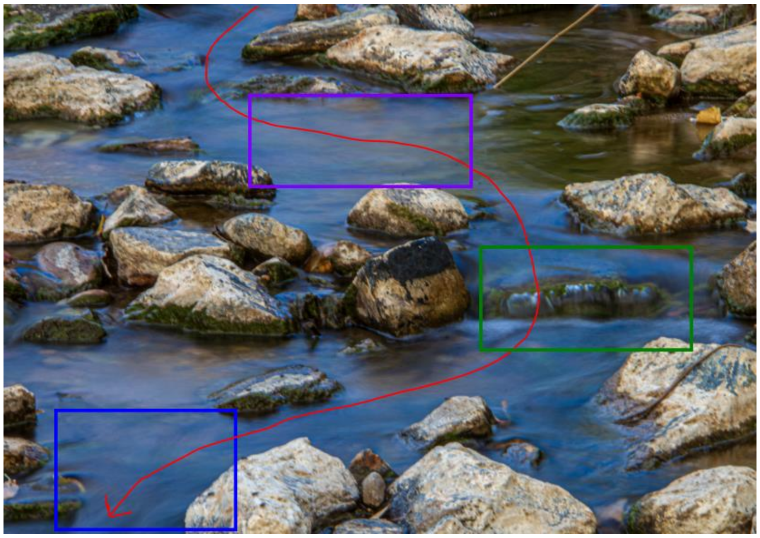

Figure 1: Labeled Enhanced Image

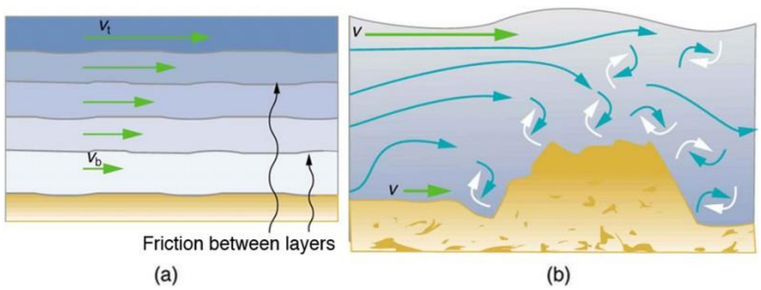

Figure 2: Borrowed from Lumenlearning.com[3]

For this visualization technique, no additional substances like dye or smoke were used; the focus was on capturing the natural flow of water. I positioned my camera on a tripod, purchased from Target, to ensure stability and prevent any motion blur. The tripod allowed for precise framing of the scene, which included a variety of features such as rocks and eddies in the stream. The stream was outdoors, with water flowing naturally. The recording took place at 5:54 PM during sunset, which provided a soft, natural light ideal for highlighting the different textures of the water. Regarding lighting, the sunset provided a warm, diffuse light, reducing harsh shadows and enhancing the visibility of details in the water. No artificial lighting or flash was used; the natural sunlight during the golden hour was sufficient to capture the dynamic movement of the water. The lighting conditions added depth and contrast to the image, making the different flow patterns more visible without requiring any additional light sources. This setup allows the image to be replicated under similar environmental conditions, particularly in the late afternoon with low, warm light.

For this photographic technique, I used a Canon EOS 60D digital camera, positioned approximately 12 feet from the stream and 4 feet above it. The camera was equipped with a Canon zoom lens EF-5 18-200mm at a 100mm focal length, which allowed me to capture both the detail and the full range of features in the scene. The field of view focused on a 4-foot square section of the stream, capturing a range of water flow characteristics, from smooth laminar regions to

[3] Lumen Learning. (n.d.). *Viscosity and laminar flow; Poiseuille's law*. In Physics. Lumen Learning. https://courses.lumenlearning.com/suny-physics/chapter/12-4-viscosity-and-laminar-flow-poiseuilles-law/

turbulent swirls. The original image size was 5202 x 3464 pixels, and after enhancements, the final resolution was 5184 x 3456 pixels. The exposure settings included an ISO of 100, a f-stop of f/36, and a 2-second shutter speed, which helped create a sharp, high-quality image while emphasizing the water flow. The longer exposure allowed me to capture the motion of the water, creating a smooth effect in the flowing areas. For post-processing, I used Adobe Lightroom Classic to enhance the image. Adjustments included increasing the saturation and brightness of cooler colors to better highlight the details in the water and surrounding environment. I also improved clarity and sharpness to bring out the finer details of the stream and rock textures. I decreased the exposure slightly to control the highlights and reduce overall noise for a cleaner image. These choices helped enhance the visual contrast between the smooth and turbulent water flows while maintaining a natural look. The combination of these settings and adjustments aimed to create a vivid, dynamic representation of the stream's motion, with clear visibility of the various flow characteristics.

The image reveals a dynamic interaction of fluid flows in the stream, capturing a variety of water behaviors as it moves over rocks and other natural obstacles. The smooth, laminar sections of the stream contrast with the more turbulent areas, where eddies and swirls are visible. The long exposure time creates a silky effect in the water, clearly showing the different flow regimes. This gives a strong visual representation of fluid physics, particularly how water behaves differently depending on the speed and texture of the streambed. I appreciate how well the image captures both the calm, laminar flow and the chaotic, turbulent areas in a single frame. The enhanced colors and sharpness draw attention to the fine details, such as water droplets and eddies. The smoothness in the flowing water, caused by the long exposure, adds an almost surreal quality that makes the movement of the stream visually appealing. One drawback of the image is the slight over-saturation in some areas, which may detract from the natural look I was aiming for. Additionally, the long exposure time, while great for capturing movement, made some parts of the stream appear too smooth, losing some of the sharpness and texture in the faster-moving water. The image illustrates fluid dynamics principles well. It visually demonstrates both what laminar and turbulent flow look like, as well as how the water interacts with obstacles to create eddies and chaotic movements. The distinction between the smooth and turbulent sections is clear, showcasing the effect of different flow velocities and obstructions in the stream. I wonder how a shorter exposure time might impact the visibility of smaller, faster-moving details in the turbulent sections. Would a higher ISO setting allow me to capture more definition in those areas without losing the overall flow effect? Additionally, could different lighting conditions (e.g., earlier in the day or using artificial light) change the depth and contrast of the water’s appearance? I believe I fulfilled my intent to capture the dynamic flow of water and highlight the natural beauty of fluid physics in a stream. The combination of slow and fast flow areas was effectively captured, showing the diversity of fluid motion. I would like to improve the balance between exposure time and clarity. A slightly faster shutter speed might retain more texture in the fast-moving water while still conveying motion. Reducing saturation in post-processing could also make the image feel more natural and less enhanced. To develop this idea further, I could experiment with capturing water flows under different environmental conditions, such as during rainfall or after a storm when the stream's dynamics change. Using different camera angles or focusing on close-up shots of specific flow features like ripples or droplets could provide more insight into smaller-scale fluid behaviors. Additionally, adding dye or particles to visualize flow patterns more clearly could deepen the analysis of fluid physics.

References

3. Lumen Learning. (n.d.). *Viscosity and laminar flow; Poiseuille's law*. In Physics. Lumen Learning. https://courses.lumenlearning.com/suny-physics/chapter/12-4-viscosity-and-laminar-flow-poiseuilles-law/

2. McLean, E. P. (2023). *Nonlinear free-surface flows, waterfalls and related free-boundary problems* (Doctoral dissertation, UCL (University College London)).

1. Yokosi, S. (1967). The structure of river turbulence. *Bulletin of the Disaster Prevention Research Institute*, *17*(2), 1-29.