DISCHARGE MONITORING

IMAGE VELOCIMETRY

PACIFIC SALMON FOUNDATION

Image velocimetry is a method used to measure stream discharge (flow rate) that utilizes a short video of the stream to calculate the speed and direction of water movement at the surface (i.e., surface velocity). It utilizes the velocity-area approach, relying on the principle that discharge is the product of the average velocity of stream flow and the cross-sectional area of the flow. An adjustment factor (velocity coefficient) is applied to the surface velocity to calculate the average velocity. The surface velocity is calculated by breaking the video down into pictures of tiny particles in the water and tracking their movement over time. Video is easy and inexpensive to acquire, and avoids having the technician enter the stream.

SUMMARY OF METHOD

There are five main steps involved with discharge measurement using image velocimetry:

1. **Site selection:** Choose a straight section of stream with uniform flow, stable bed and banks, and minimal turbulence. Ensure clear visibility of the water surface from the intended camera position.

2. **Installation:** Securely install a clearly visible staff gauge (see related summary). Install at least four fixed control points (e.g., rebar stakes) at the stream edge to define the measurement area and enable geometric referencing in the video analysis.

3. **Surveying:** Survey the stream cross-section along a transect near the staff gauge and measure horizontal distances between all control points.

4. **Recording:** Record a short, stable video (e.g., ~15 s) of the water surface (oblique or nadir position) while ensuring all control points and the staff gauge are visible in the video. Take a corresponding staff gauge reading.

5. **Data processing:** Use specialized software (freely available) to correct video instability and extract individual frames for analysis. Identify the region of interest (between control points), define the cross-section, and input the staff gauge reading. The software computes surface velocities, applies a velocity coefficient to calculate depth-averaged velocity, and calculates discharge, producing output data and diagnostic charts.

Photo credit: WaterSmith Research Inc.

IMPORTANT CONSIDERATIONS

After initial set up, the ongoing field monitoring is simple and requires only basic training for non-technical personnel. However, initial set up of the site infrastructure and occasional re-surveying are somewhat complex, and the data processing is highly complex. The initial set up, re-surveying, and data processing require a trained technician.

The cross-section requires resurveying whenever the channel changes shape (e.g., following an extreme peak flow), and the distance between control points requires remeasuring after a disturbance (e.g., following winter ice cover).

The method is problematic for stream conditions where water movement is not visible in the video (e.g., slow, meandering flow). In these conditions, the water surface can be seeded (e.g., distributing rice cereal on water); however, other flow monitoring methods are likely more suitable.

High resolution video is required (e.g., minimum 1080p for streams <10 m wide; 4K for streams >50 m wide). Nadir video (i.e., drone) is preferable for medium and large streams (e.g., >10 m wide).

STREAM CHARACTERISTICS

- Range of measurable discharge is generally unlimited (constrained by other factors)
- Well suited to high-velocity flow
- Not suitable for low-velocity flow where water surface lacks texture
- Not suitable for ice cover
- Extensive sun reflection or partial shading on water surface can be problematic

MEASUREMENT CHARACTERISTICS

- Typically manual data acquisition, but can be automated and connected to telemetry for real-time monitoring
- Distributed measurement across stream
- Point measurement along stream network
- Accuracy varies with site conditions

SITE ACCESSIBILITY FACTORS

- Suitable for remote foot access
- Can avoid entering stream during high flow
- Initial set up involves medium-sized equipment (e.g., rebar, staff gauge, survey level, stadia rod)
- Ongoing monitoring involves small equipment (e.g., phone camera, drone <250g)

SCALE OF EFFORT: INITIAL SET UP

Equipment cost: low
Field time: moderate; ~1 day
Field expertise: moderate; knowledge of channel morphology, flow hydraulics, and channel surveying

SCALE OF EFFORT: ONGOING MONITORING

Equipment cost: negligible
Field time: very low; <15 min
Field expertise: low; requires basic training (moderate for periodic channel re-surveying)
Analysis time: low; <1 hr/measurement
Analysis expertise: high; complex software

PRODUCTS TO CONSIDER

Software: RIVeR, Fudaa-LSPIV, Ivy

ADDITIONAL RESOURCES

Biggs et al., 2021
Bomhof et al., 2024
Bureau of Meteorology, 2021
Saletti, 2024
Salmon Habitat Restoration Center of Expertise, n.d.
van de Giesen et al., 2023