Flow Observations

Flow (discharge magnitude) is an essential observation made during the collection of water samples from rivers and streams. The water quality of a river or stream can change dramatically during and immediately following a precipitation or snow melt event. **It is important to consider the flow conditions at the time of sample collection to provide more context for the resulting TP/TN/Cl values when interpreting water chemistry data.** This can aid in source identification. For example, a high chloride concentration under low flow may indicate groundwater contributions. Additionally, only base flow measurements are used when applying the Vermont Water Quality Standards.

The VT DEC records these stream flow related observations (flow level and flow type) during the collection of a stream sample and requires its use in conjunction with all stream water quality sampling.

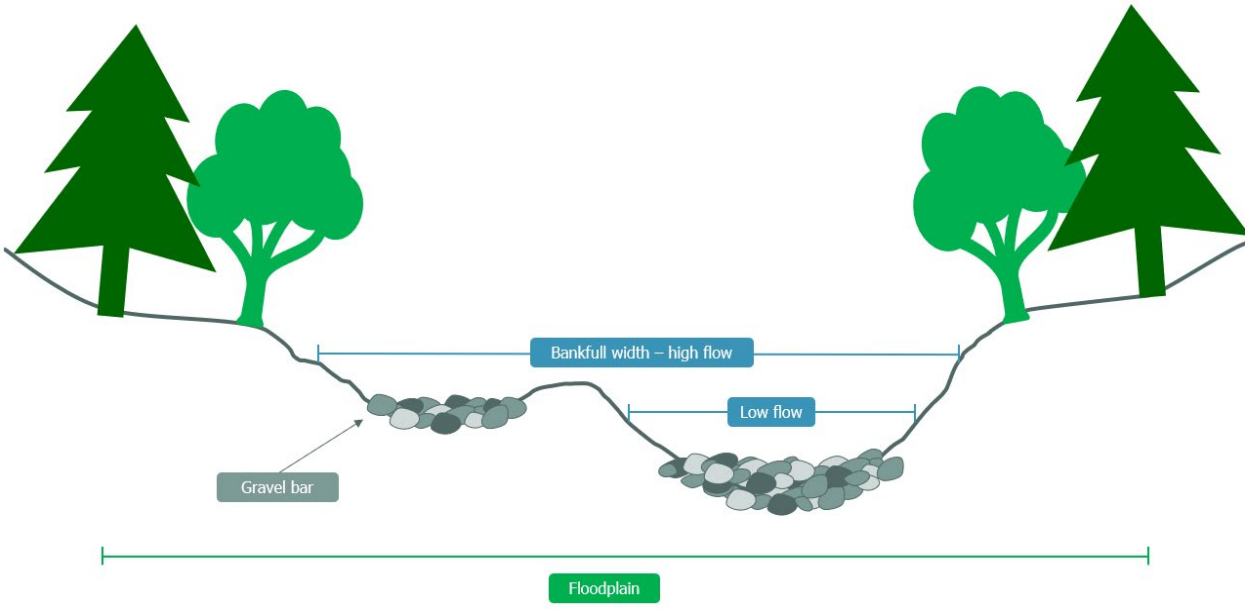
Flow Level

Flow level can be described as:

- Low
- Moderate
- High
- Flood

A diagram of stream flow levels in an example stream is provided in Figure 7. Example photos of different flow conditions can be found on the LPP website under the Training and Education section.

Figure 1. Diagram of stream flow levels in an example stream



Low – Stream conditions are low relative to the entire range of flows experienced at site (less than or equal to these levels 25% of the time or the 25th percentile).

- Generally, these occur during late winter (January-February) and summer (July-September).
- Often the streambed is partially dry with gravel bars exposed, and it is possible to walk along the edge of a dry streambed.

Moderate –Stream is at a mid-level or average streamflow conditions, or most typical flows experienced in the stream (levels experienced 25-75% of the time).

- Can occur at any time of year.
- ~90 – 100% of the stream bed is under water, but the water has not yet risen to the top of the sharp incline of the stream bank.
- May also occur when flow speed is very slow even if the water level is at the top of the stream bank.

High –Stream is well-above an average level of flow (greater than or equal to these levels only 25% of the time or the 75th percentile).

- Generally, this occurs during spring and fall but can occur due to rainfall any time of year.
- Stream is full from bank to bank ("bank full flow") and water is moving very quickly, but not spilling onto floodplain.

Flood: Stream is exceeding bank full levels and accessing floodplain (if exists).

- Generally, this occurs less than 5% of time.
- Also indicated by submergence or active transport of terrestrial and woody vegetation.
- **Do not sample during flood conditions due to safety.**

Flow level does not simply refer to how high the water is reaching up the sides of the stream bank (although it often correlates). **Flow level refers to both the volume of water in the stream and the speed the water is flowing.** Streams may be full bank to bank, or bank full, but if the water is passing through very slowly, the flow level would likely be moderate, not high. High volumes of water but slow speeds of flow typically occur with low gradient wetland streams, or when a stream is backed up by an undersized or blocked culvert or beaver dam.

Note that flow level is a subjective observation that is based on your understanding of what typical, low, or high flows look like at a specific stream site. The above are guidelines for how a typical stream may look during each of the flow levels but may not be the case for all streams.

Flow Type

Flow type can be described as:

- Base flow
- Freshet
- Hydro

Base flow – A stream's flow is at a relatively constant level at the time of sampling, neither rising nor dramatically falling in direct response to a rainfall event or snow melt runoff. Subsurface flows account for almost all water reaching streams. The hydrographs of nearby gaged streams have not begun to rise, have fallen to a similar level of that before the flow level rise began, or have leveled off to a steady but higher flow level. A base flow can exist under low, moderate, and less commonly, high flow levels, but not under a "flood" level. The USGS maintains the National Water Dashboard which has real-time streamflow data. The hydrographs associated with the gages mapped on this dashboard are useful tools in identifying base flow conditions.

Freshet flow – A stream's flow is actively rising or falling in response to a rain event or snow melt. The hydrograph of a stream shows an increase or decrease in flow and has not leveled off to the pre-event flow levels or stabilized to slightly higher than pre-event levels. Streams can be turbid under these conditions due to stormwater runoff and increased re-suspension of stream bed sediments. **Freshet flow can co-occur with low, moderate, or high flow levels**.

Freshet events can last for hours to days depending on the intensity of the event and the size of the watershed. Generally, as little as **0.1 inches of rain fall in a 24-hour period prior to sampling is enough to induce a freshet event**. Heavy rain or snowmelt will result in longer lasting freshet events. **The smaller the stream and watershed, the less rain/snowmelt is needed to cause freshet flows.** "Flashier" and more extreme rapidly rising and falling flows are often seen in these small streams as well, so the stream will return to stable flow levels faster than larger steams (usually within 24 hours depending on the amount of rain/snowmelt). More moderate flow level rises occur in the larger, higher order rivers during freshet events, and the freshet event can take longer to occur after the rain or snow melt begins but last longer after it ends (up to 24-48 or more hours depending on the amount of rain).

Hydro flow – A stream's flow level is rapidly rising *solely* due to the abrupt release of water from an upstream man-made dam. A rise in streamflow with no recent precipitation or snowmelt events and when similar rises are not observed for local stream gauges are good indicators of artificial releases from dams. The Vermont Natural Resources Atlas, available at http://anrmaps.vermont.gov/websites/anra/, also contains a watershed protection layer depicting known dams throughout the state, including whether they are operated for generation of electricity.

Note: the occurrence of natural freshet flows in direct response to rainfall or snowmelt are still possible below such facilities.

If any site has dried up, flow has ceased, or is too low to sample, both flow level and flow type would be recorded as "No Flow". Note that no flow does not pertain to very slow moving, low gradient, typically wetland streams, which may not have visible stream flow but are flowing slightly and are often deep enough to sample.

Figure 9 presents a hydrograph of the discharges in the Black River over time and demonstrates how the flow changes drastically in a season. Sharp inclines in the daily flow line indicate an increase in flow due to a freshet event caused by either rain or snow melt runoff. The highest flows occurred in April and May, while the lowest flows occurred in the summer and early fall.

As demonstrated by the percentile lines on the graph that show the distinction between low (below the dashed line), moderate (between the lines), and high flow levels (above the dotted line), freshet events can occur with all three flow levels. Note that the highest 25% of flow conditions would all be classified as freshet. **High flow level and base flow type can co-occur, but it is uncommon**. Typically, this only occurs when ground water levels are very high due to a nearby groundwater spring or frequent heavy rain and saturated soils that last for long periods of time.

Figure 2. Hydrograph of 2018 daily flows in the Black River indicating freshet and base flow types