RWater Module 2
Effect of Rainfall Intensity on Streamflow Response

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Learning Goals

From the concepts of Hydrologic Cycle, we already understand that rainfall is the key factor controlling the flow in streams or rivers. The rainfall-streamflow relationship is not unique. With the same total amount of rainfall, flow in the nearby stream can respond differently depending on the rainfall intensity over a particular area. In order to launch students' primary level of insights on the rainfall-streamflow relation, this module consists of four hypothetical examples, supplemented with the definitions of some fundamental hydrologic terminologies. After completing this module, students will be able to:

i. get familiar with rainfall hyetographs and streamflow hydrographs, and build the concepts of Peak Discharge and Lag Time
ii. understand how the streamflow responds with different rainfall intensity situations, based on hypothetical examples.

Hyetograph and Hydrograph

A *hyetograph* is a graphical representation of the distribution of rainfall over time. It is usually represented by a bar graph showing rainfall amount versus time. A *hydrograph* is a curve showing the streamflow versus time. The streamflow or discharge is basically the rate of flow (volume of water per unit of time) and is typically expressed in cubic meters or cubic feet per second (cms or cfs). Streamflow is measured at a particular point in a stream/river and is typically time variant. Hence, one hydrograph is valid for only a specific location along the stream.

Following are some relevant terminologies, being used very often in the study of hydrologic sciences.

Rainfall Intensity: amount of rainfall occurring in a unit of time (example: inch/hour)

Peak Discharge: the highest point on the hydrograph when the rate of discharge is greatest

Lag Time: the time difference between the peak of the rain event and the peak discharge

Rising Limb of Hydrograph: represents the rapid increase in flow resulting from rainfall

Falling Limb of Hydrograph: when discharge decreases and the water level in the river falls

See Figure 1 to visualize the above described terminologies.

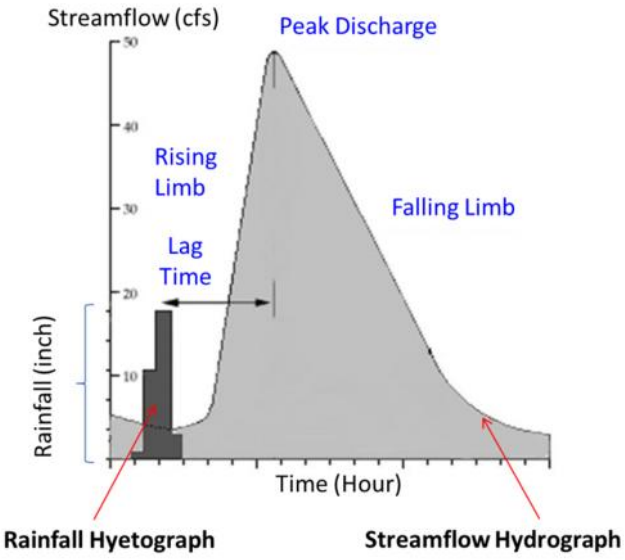

Figure 1

Effect of Rainfall Intensity on Hydrograph

In simpler words, 'High-intensity' rainfall means high amount of rainfall within a very short period of time. 5 inch of rainfall occurring over 5 hours duration can be considered as a high-intensity event compared to the same 5 inch of rainfall occurring over 10 hours (intensity: 1 inch/hour and 0.5 inch/hour, respectively).

In Figure 2, four hypothetical rainfall events (Event 1 to 4) are presented in which the same 1.25 inch of rainfall is distributed in four different ways such that they have various rainfall intensity values.

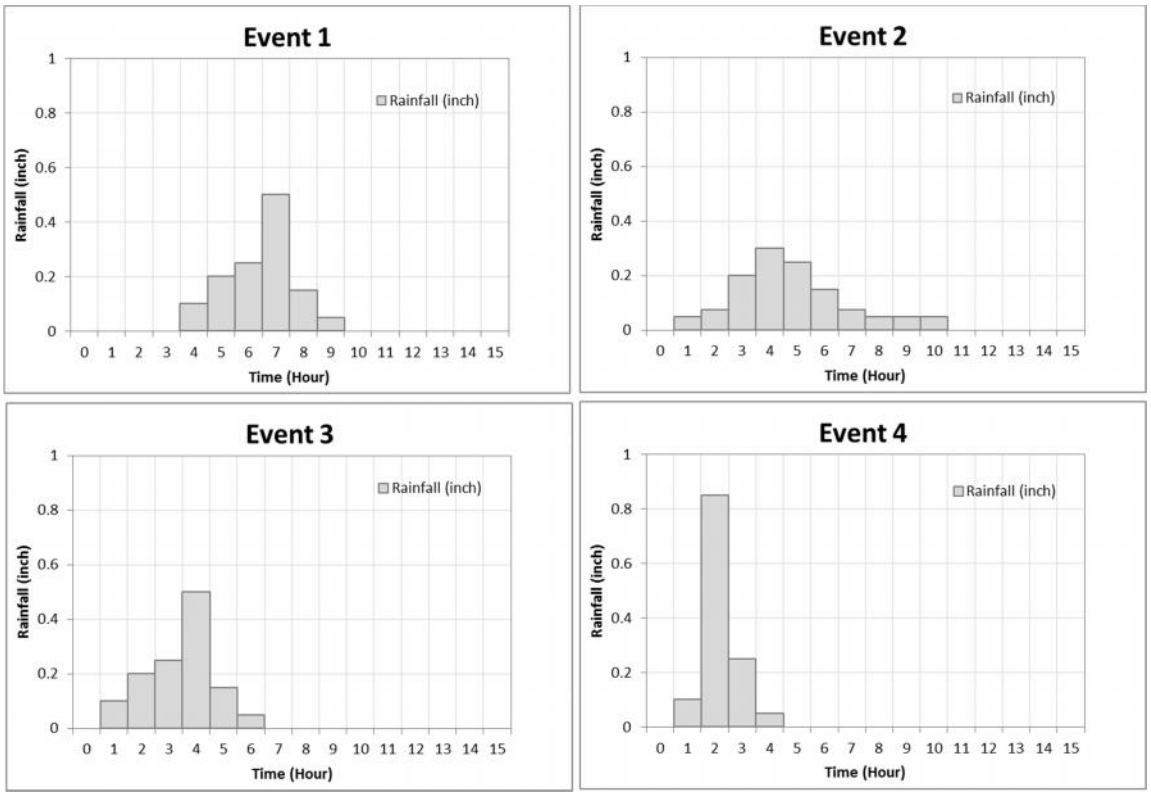

Figure 2

Now, read these graphs carefully and comment on the following statements by stating TRUE or FALSE:

1. Events 1 and 3 have the same intensity except they have different temporal distribution of the incident rainfall. **TRUE/FALSE**
2. Event 4 represents the highest intensity rainfall out of the four cases. **TRUE/FALSE**

Intensity and the temporal distribution of a rainfall event influence streamflow hydrograph in the following manner:

- Rain water falling over the ground surface infiltrates into the soil until it reaches a stage where the rainfall amount exceeds the amount of water that can be absorbed by the soil at any instant (soil's infiltration capacity).

- At this stage, soil becomes saturated and can no more receive water.
- In case of a high-intensity rainfall event, rainfall quickly exceeds the infiltration capacity of the soil. As a result, rather than entering into the ground, rainwater starts traveling over the surface (as runoff) very shortly after the rainfall begins. This causes rainwater to reach nearby stream very quickly, resulting into sharp change in the rising limb of the hydrograph.

Thus, an inch of rain in an hour will produce more flow in the stream (high peak discharge) with a shorter lag time than an inch of rain that falls throughout a whole day. Eventually, discharge falls as the rainfall event comes to an end.

In Figure 3, Events 1 and 2 are associated with appropriate streamflow hydrographs, whereas for Events 3 and 4, several potential options for an appropriate hydrograph are provided (dotted lines). Now, from the conceptual discussion being made in the earlier paragraph as well as the hydrographs shown in case of Events 1 and 2, try to find out which one of the dotted lines suits best for Events 3 and 4, respectively.

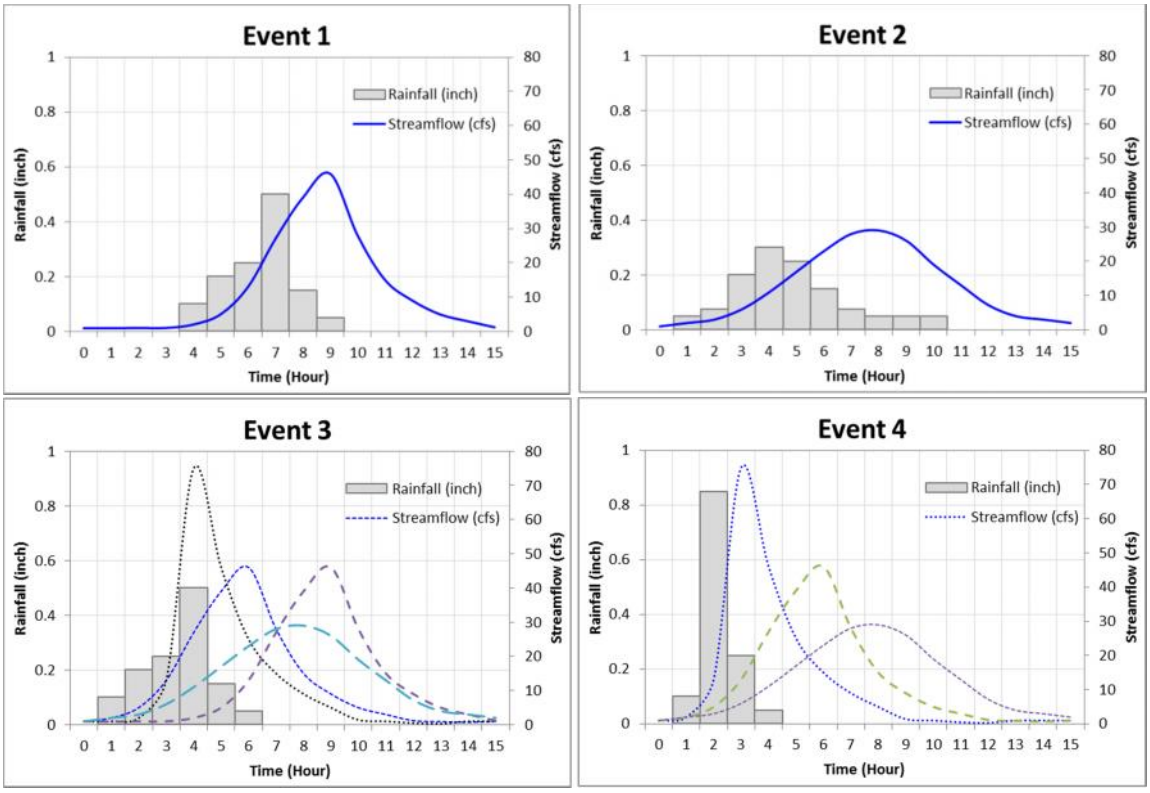

Figure 3

Quiz

Answer the following questions:

1. In the 'most appropriate' hydrograph for Event 3, what is the lag time?
   a. 2 hours
   b. 5 hours
   c. 4 hours
2. In the 'most appropriate' hydrograph for Event 4, what is the Peak Discharge?
   a. 75 cfs
   b. 50 cfs
   c. 30 cfs
3. State whether the following statement is correct: "1 inch of rain in 2 hour will produce higher peak discharge with a shorter lag time than 2 inch of rain that falls in 2 hours"