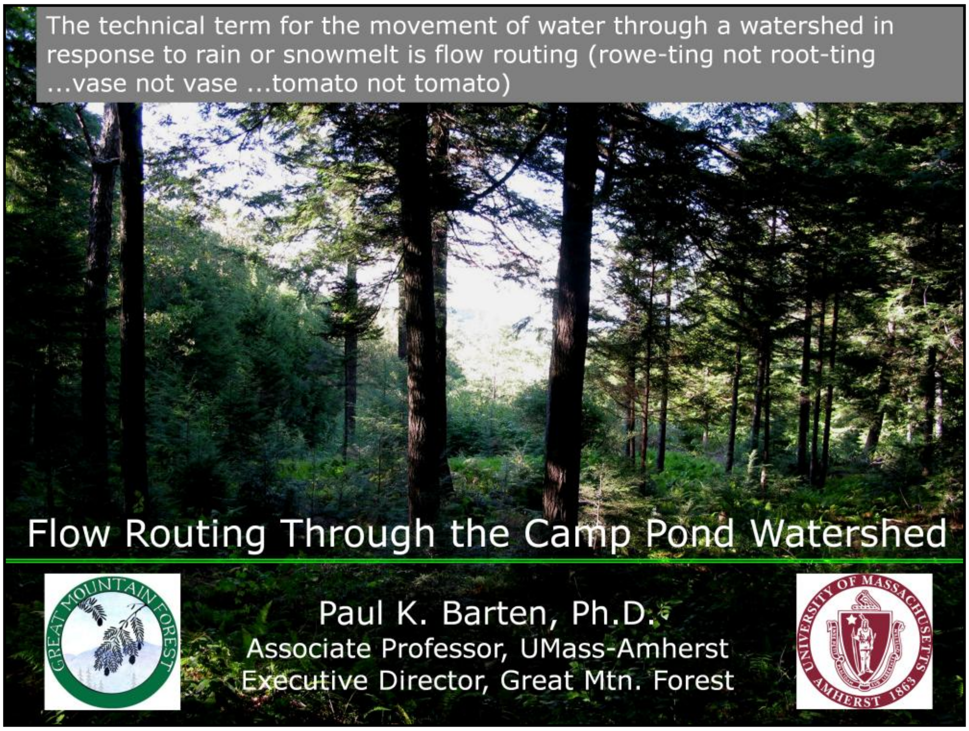
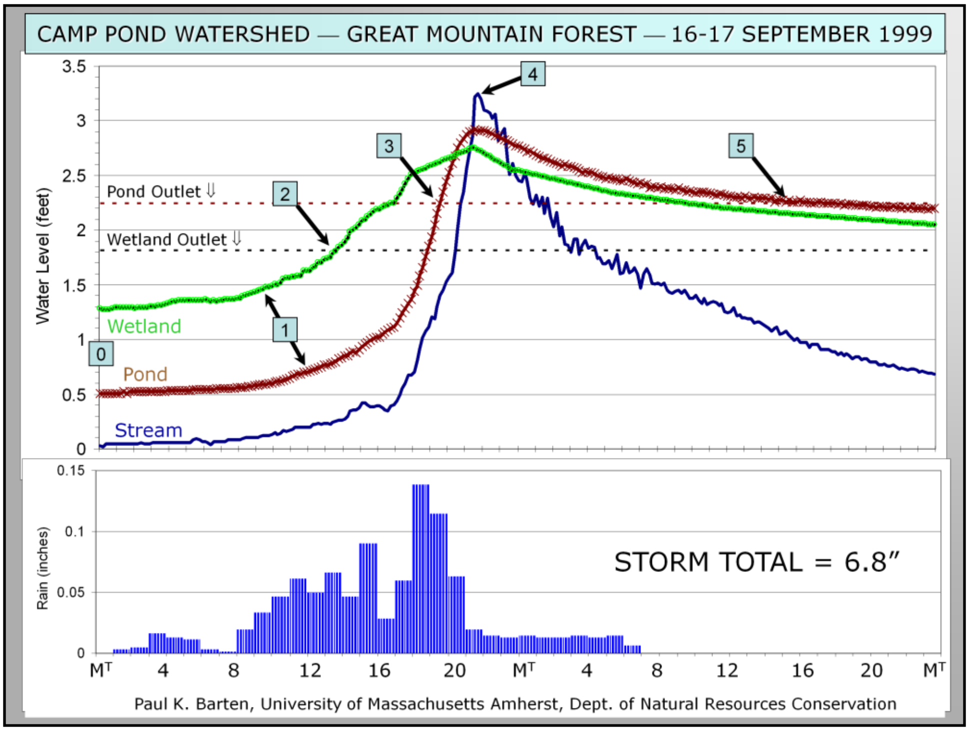


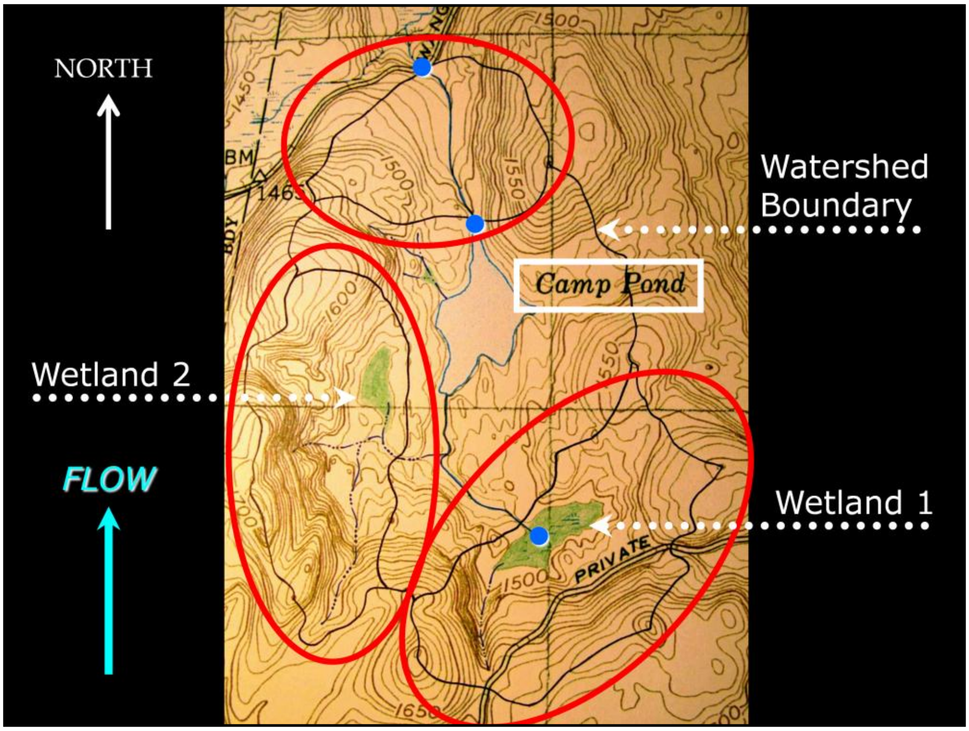
The technical term for the movement of water through a watershed in response to rain or snowmelt is flow routing (rowe-ting not root-ting ...vase not vase ...tomato not tomato)



Here is what happened nine years ago on the Camp Pond watershed during an even larger event – Tropical Storm Floyd, 6.8”

We are going to step through the numbered time points in a few minutes.

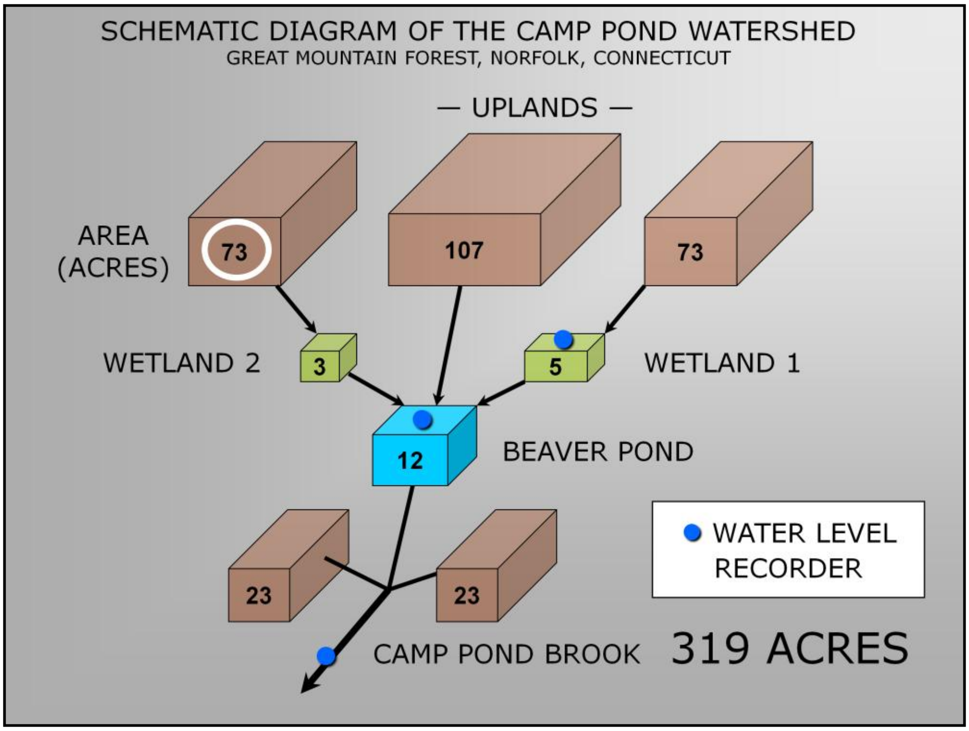
First, let’s take a look at the study site.



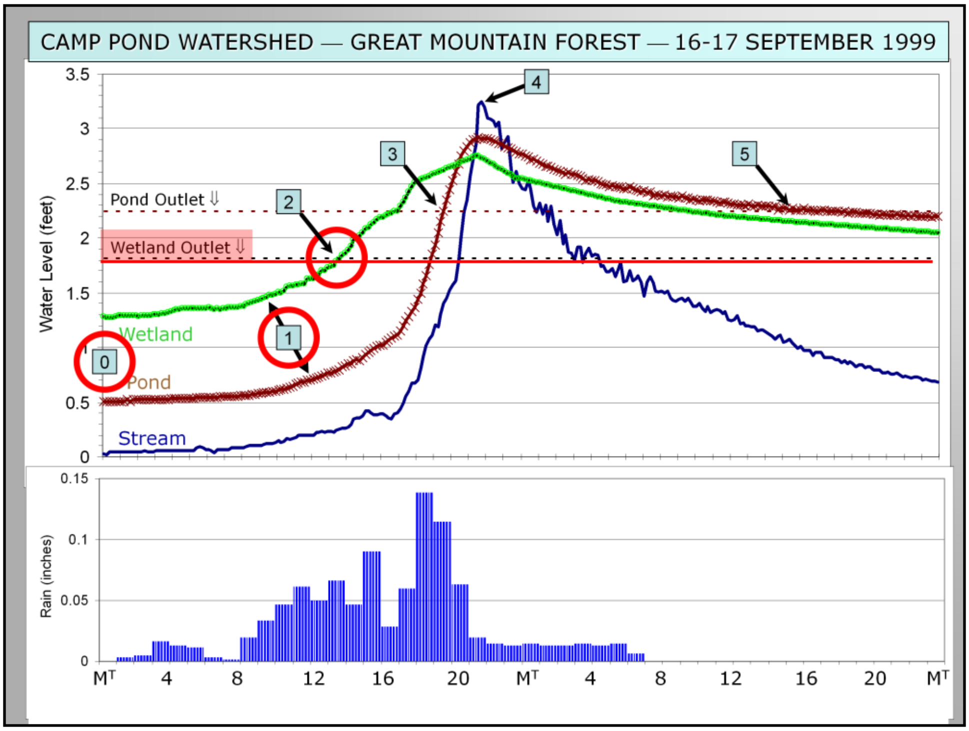
I starting working on this site in 1991 after doing my dissertation work on much smaller and simpler experimental watersheds in northern Minnesota. I reasoned that this watershed would force me to confront the inherent complexity of most parts of southern New England ...and in so doing I would learn more about the hydrologic structure and function of the landscape.

Describe subwatersheds (nested) and instrumentation (synchronized clocks) ...paired with Norfolk 2 SW

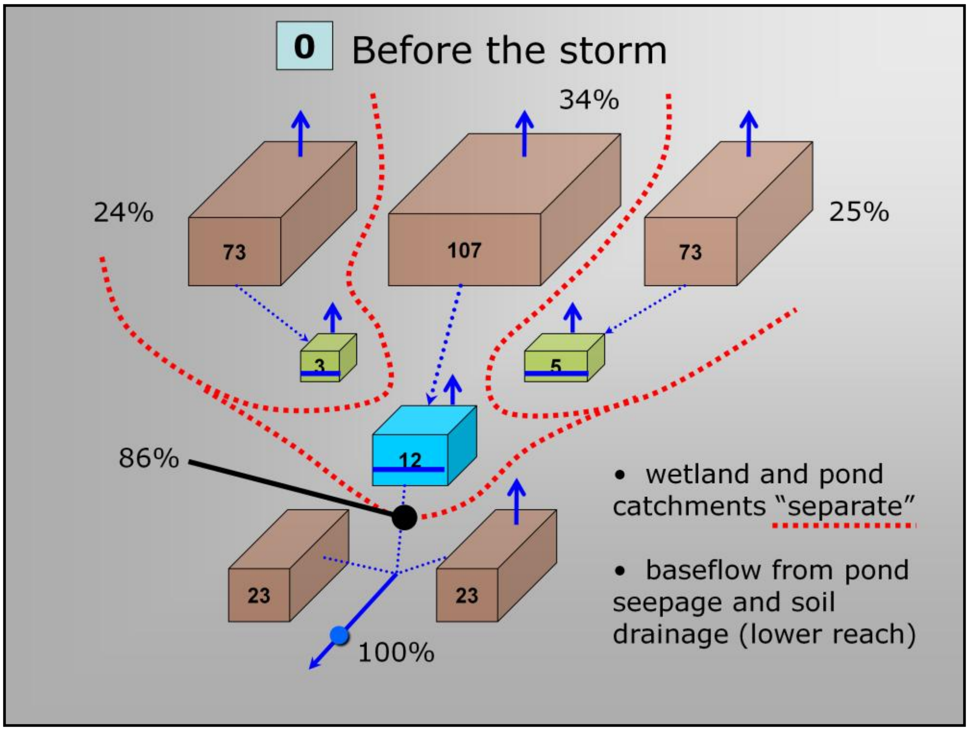
Wetland 2



Here is a schematic diagram – a cartoon or definition sketch if you will – that we are going to use to help interpret the water level and streamflow changes associated with the tropical storm.



Time points 0, 1, 2



Before the storm begins the subwatersheds are hydraulically disconnected. The upward arrows indicate the evaporation of water back into the atmosphere.

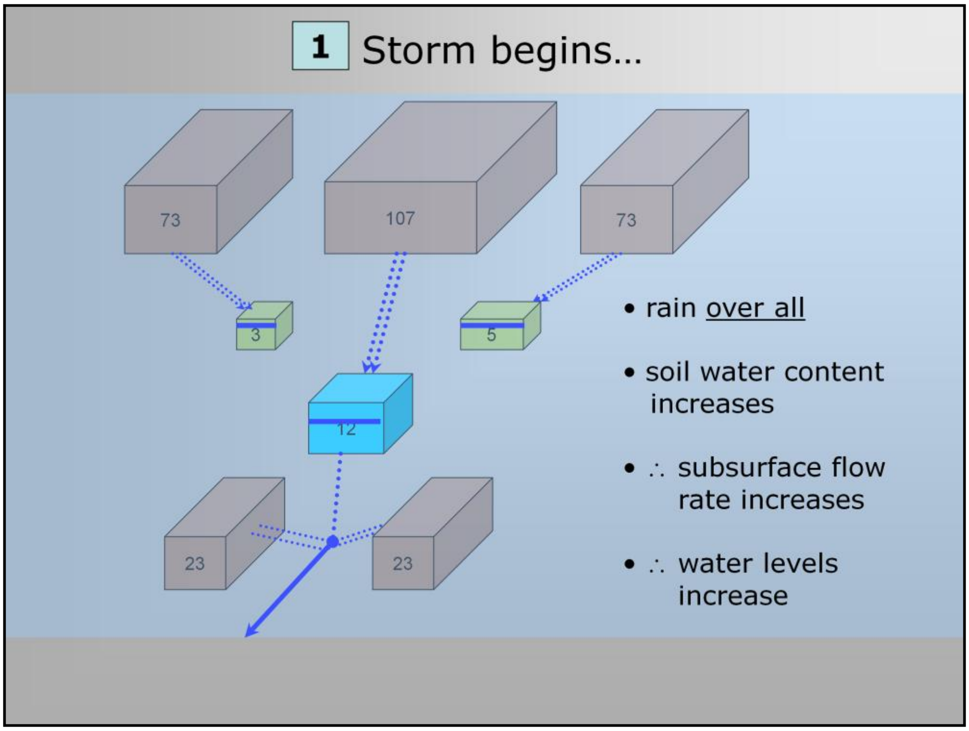
As you can see the wetlands each control about ¼ of the watershed. The beaver pond controls 1/3 of the watershed. Taken together they control 86% of the watershed.

The water level in the wetlands was about 6" below the controlling outlet elevation

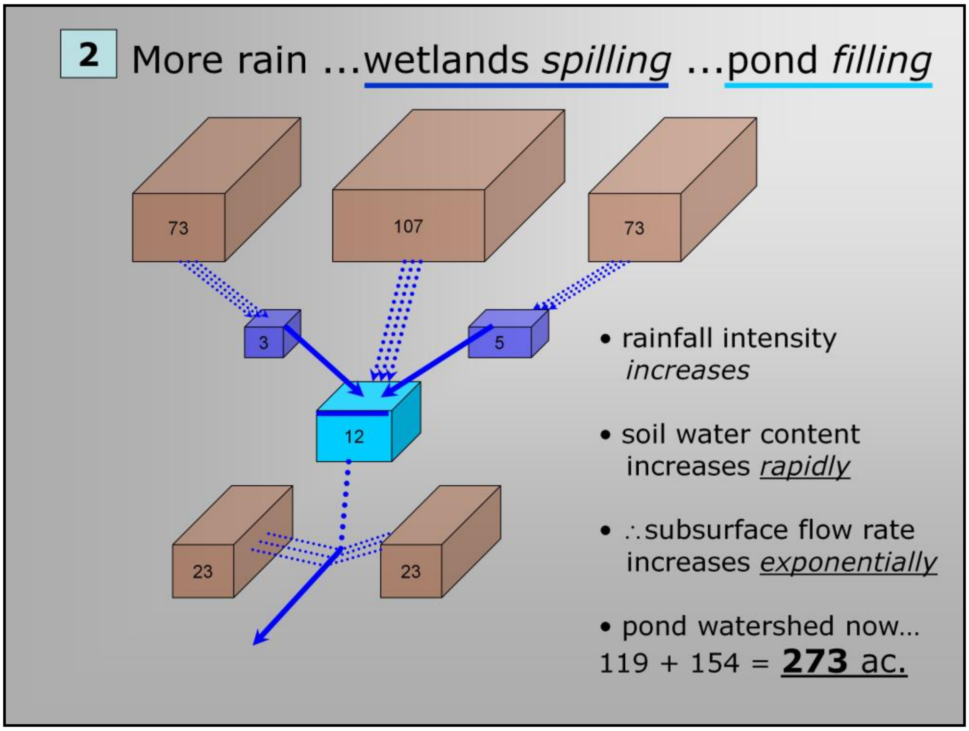
The water level in the beaver pond was almost 2' below the top of the dam

What little streamflow there was came from seepage through and under the dam and from the soil in the 46 acres that are adjacent to the lower reach of the stream.

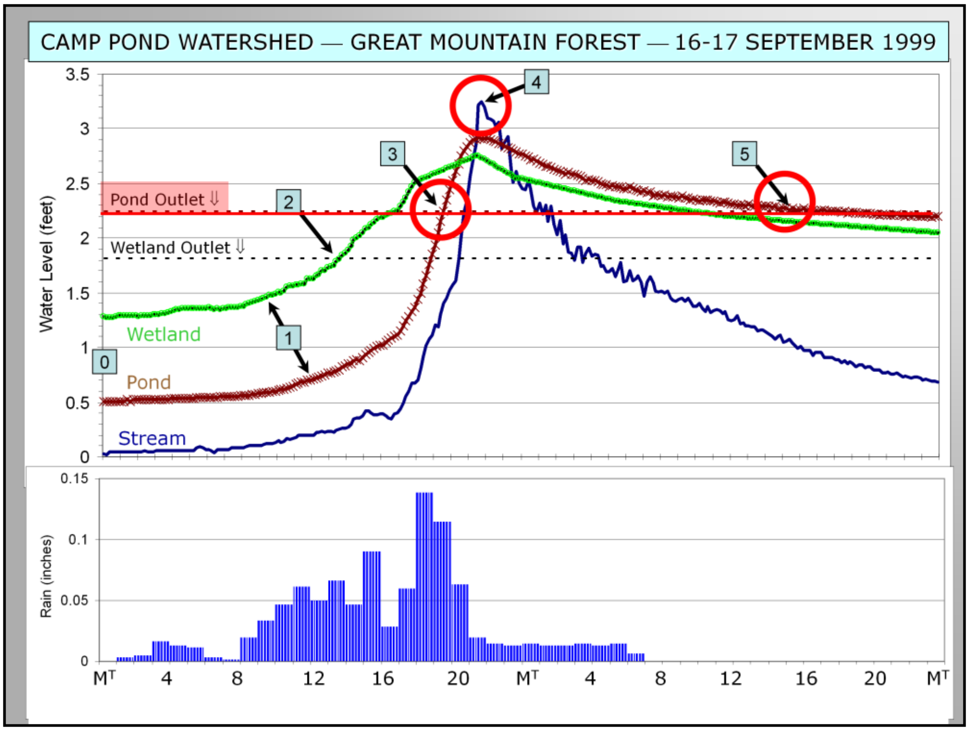
This combination of available storage and subwatershed separation has an important influence on the overall streamflow response to a very large storm.



It may be self-evident, but it’s important to remember that rain is affecting the entire area. Some of it is landing directly in the wetlands, pond, and streams. The remainder is steadily increasing the water content of the soil ...and as result the rate of subsurface flow down the slopes into the wetlands, pond, and streams.



As the storm continues and increases in intensity so does subsurface flow. Then we reach the notable point when the wetlands fill to their outlet elevation and begin to spill water downstream into the pond. At that time point the pond's watershed area increases from 119 to 273 acres, 86% of the watershed, and, as a result, the rate at which the pond fills more than doubles.



Now the last three time points

3 when the pond spills

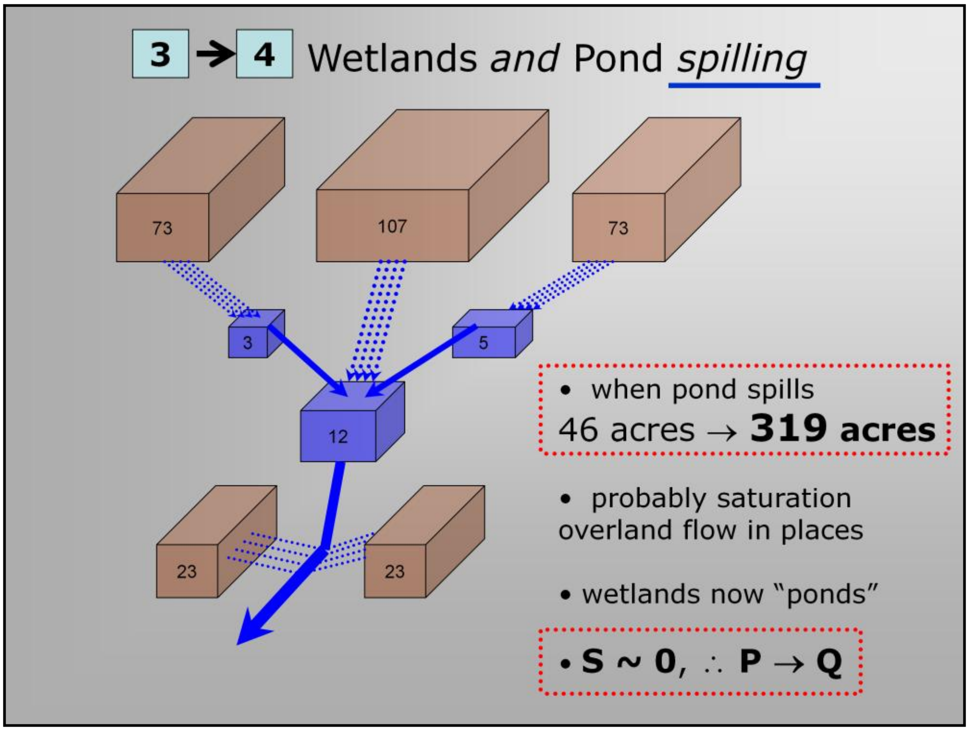
4 when the stream reaches its peak water level and flow rate

And 5 when the pond water level recedes

One effect of the pond, even when it is full, is to detain or delay water flow simply because it is relatively flat. In other words, absent the beaver dam there would be a stream sloping through this valley ...with substantially higher flow velocity – much less travel time from A to B.

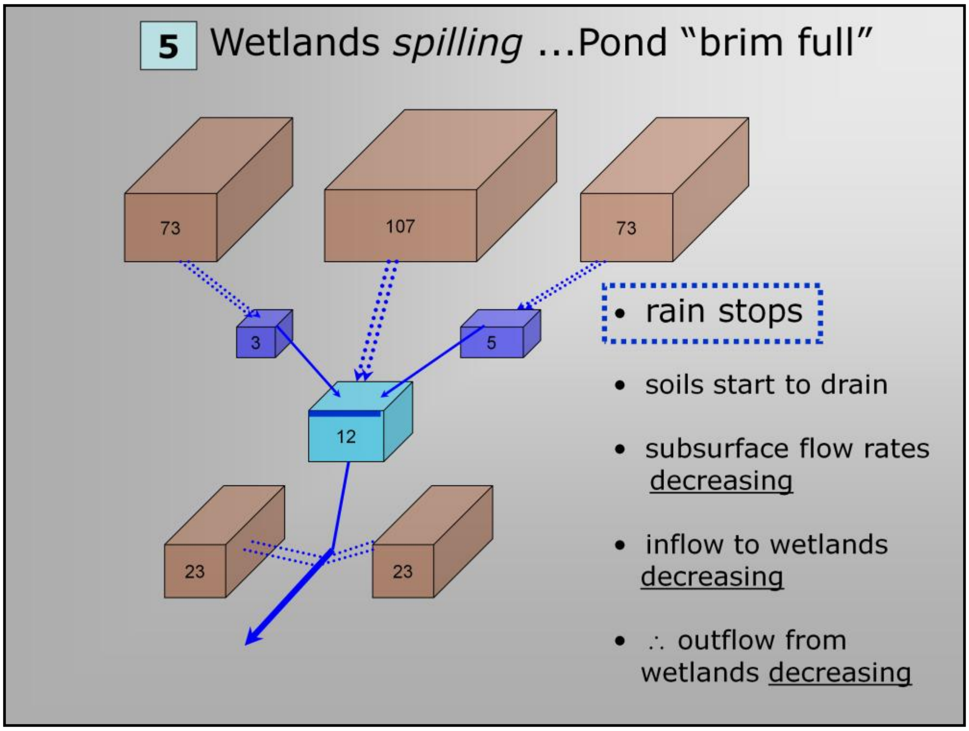
Beavers very proficient hydraulic and structural engineers. Many generations have built and maintained a gravity arch dam with a very high capacity.

At the peak water level of 2.9' (H= 0.7') during this storm ...there was about 70,000 gallons/minute going over this dam with little or no damage.

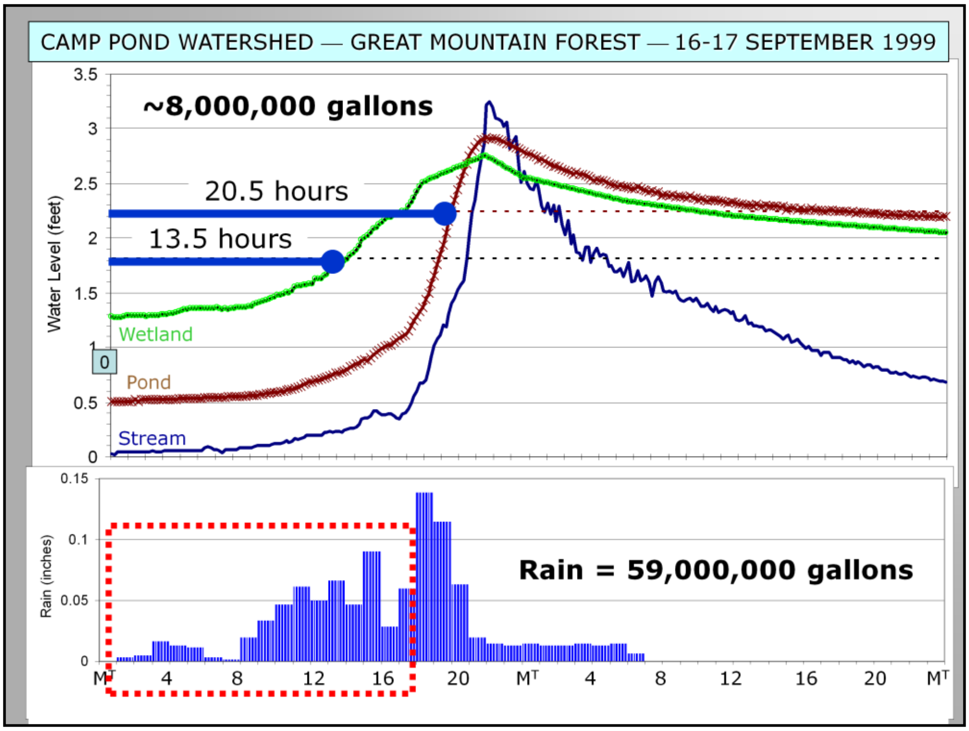


At the instant the pond begins to spill the entire watershed – all 319 acres – is connected. Available storage in the wetlands and pond is filled and any "new" rainfall is immediately converted to streamflow.

Here is the maximum water level of 3.3’in what ordinarily is small brook that you can cross in knee boots.

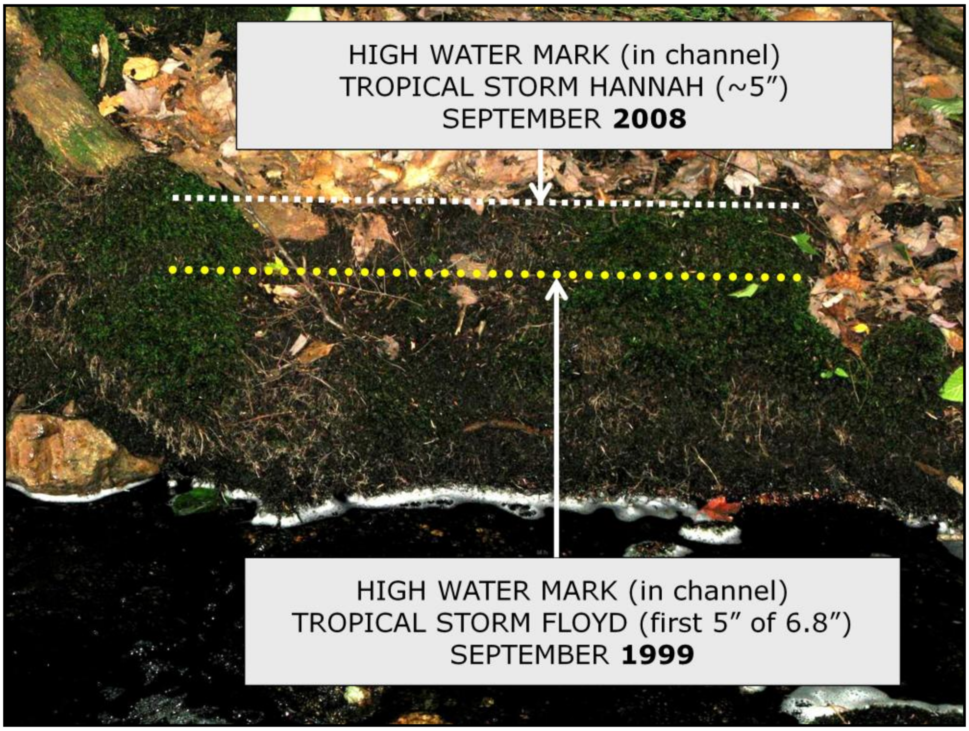


Shortly after the rain stops and the wave passed through the watershed the process begins to reverse ...decreasing soil water content (due to drainage and evaporation), decreasing subsurface flow, decreasing water levels in the wetlands and pond. Heading back to the hydraulically separated condition unless or until another rain event comes along.



So what? So what was the net effect of the wetlands and the pond on the overall streamflow response of this 319 acres of southern New England forest?

In volume terms it was not unimpressive ...8 of 59 million gallons were retained in the watershed. But the more important effect is the time delay and de-synchronization of flow. This delay directly affected the fate of this substantial portion of a very large storm.



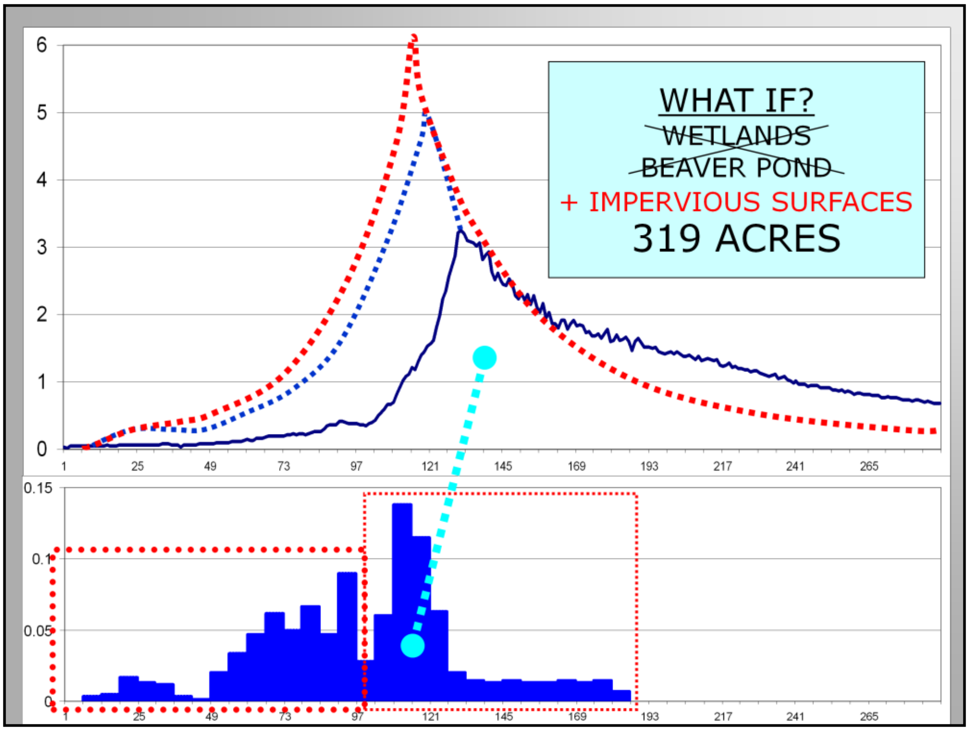
Was this just a fluke or an unusually favorable set of conditions. The short answer is NO.

Remember that I decided to present this aspect of my work at GMF because of 5' storm we had a few weeks ago. Well here is the high water mark from that event, compared with the high water mark for the first 5" of the 1999 event.

Why are they different? Think about this past summer relative to long-term averages.

Wetter ...less available storage at the beginning of Hannah ...lower %retained ...less time to fill and spill ...more time as 319 acre watershed than two or three or four separate subwatersheds.

After 5" of rain during Tropical Storm Floyd the stream was 1.85'



So based on this ten minute forest and wetland hydrology course you should be able to confidently answer this question.

Put another way, what would have to happen to this rainfall?

Now what happens if we cut some of the forest and add roads, driveways, and rooftops?

(without appropriate care in mitigating to changes).

What must happen to storage? Travel time? Stormflow volume and time to peak?

Effects on development on stormflow volume, peak, and timing

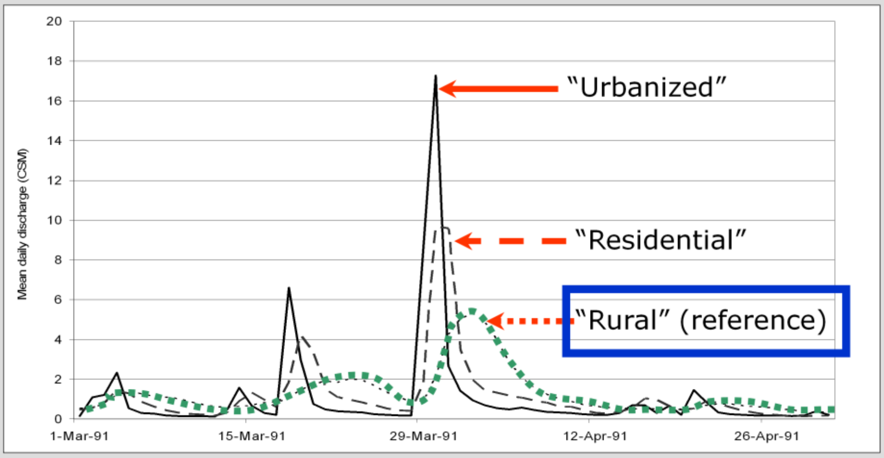
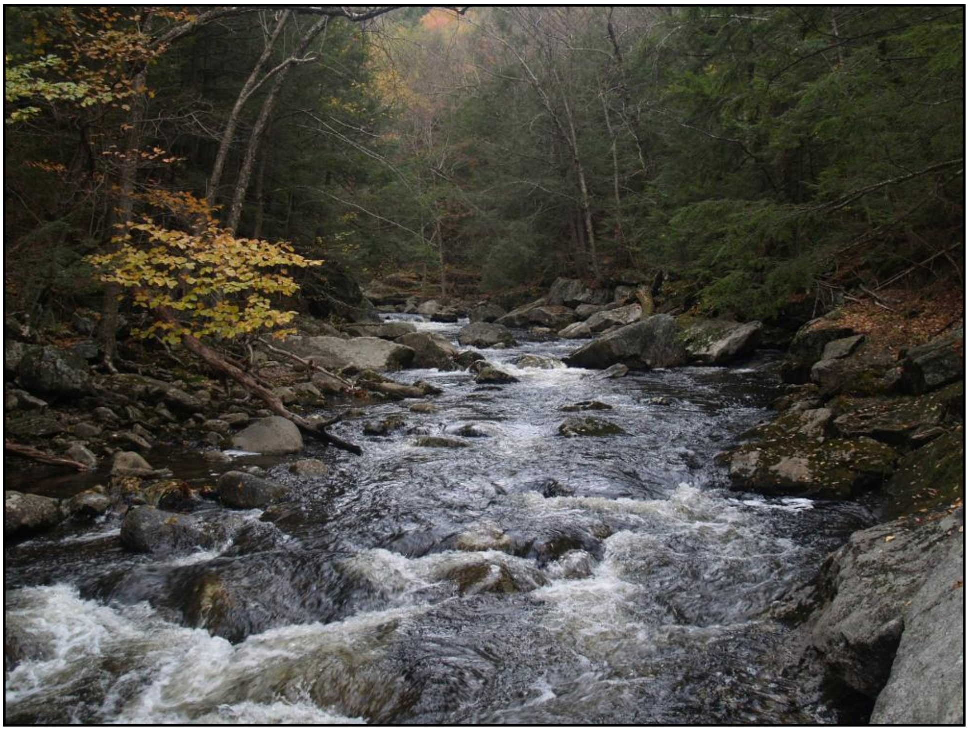


Figure 8.7 — Normalized mean daily discharge ([ft^3/sec]/mi^2) for three gaging stations in the Chickahominy River watershed, Virginia, used by Focazio and Cooper (1995). Solid line = Upham Brook (urbanized, 38 mi^2); Dashed line = Chickahominy River at Atlee (residential, 62 mi^2); Dotted line = Chickahominy River at Providence Forge (rural, but includes Upham and Atlee subwatersheds, 252 mi^2). The period from 29 March to 12 April 1991 corresponds to "Storm 4" in Figure 8.6. Data source: http://waterdata.usgs.gov/va/nwis/discharge? (de la Cretaz and Barten, 2007)

Not bad for a ten minute hydrology course

If we propose to avoid, prevent, or mitigate the effects of land use on streamflow and water quality we have to begin with a clear and accurate understanding of the hydrologic structure and function – over the long term, not just of few months of so-called site assessment – if we really mean all the political and regulatory rhetoric about achieving sustainable development.



Hubbard River, Granville State Forest, Massachusetts

This water flows into the Barkhamsted Reservoir, the water supply for 400,000 people in the metro-Hartford area.

Photo by Paul K. Barten