FACT SHEET

September 2010

Uncertainty in River Forecasts

Middle Atlantic River Forecast Center

A National Weather Service (NWS) River Forecast tells you how high the river will be at specific times in the future (Figure 1). River forecasts are based on complex computer modeling and professional judgments made by hydrologists. Users of forecast information need to know that there is some uncertainty with every forecast. This fact sheet outlines the 12 factors that can increase uncertainty in river forecasts.

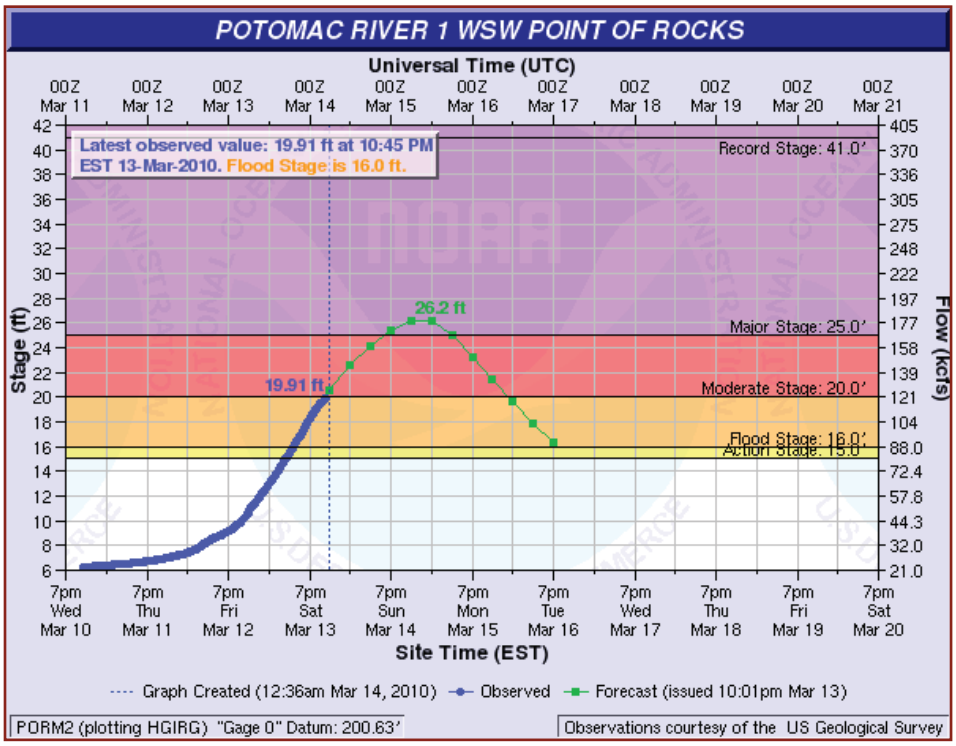
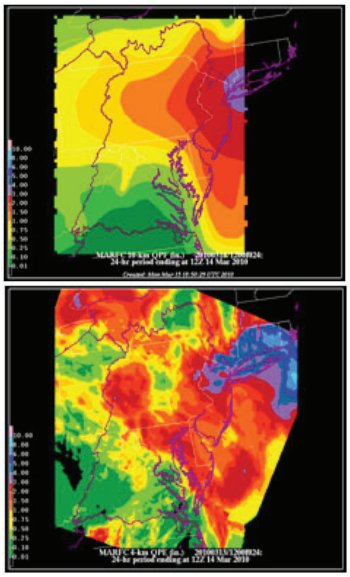


Figure 1: River Forecast for Potomac River - green dotted line illustrates the forecasted river stage for a future, three-day period.

Uncertainty Factors

- **Forecasting Precipitation** – If heavy rain falls even a short distance from where it was forecasted to occur, it may fall in a different watershed and send runoff into that neighboring watershed. Timing and intensity of precipitation events also affect the amount of runoff reaching rivers (Figure 2).

Figure 2: Forecast (top) vs. Actual Rainfall



Although heavy rain was forecasted for northern New Jersey during a spring flood, higher amounts actually fell, which led to river forecasts being updated to major flood category.

- **Past Precipitation** – The precipitation data used by the NWS is a combination of measurements from rain gages and rainfall estimates from Doppler weather RADARs.

  The weather RADAR precipitation estimates can have inaccuracies. Underestimation of rain can occur when the RADAR beam does not intersect the strongest portion of the storm, or if the beam is blocked by higher terrain. Underestimation can also occur in tropical storms where raindrop size tends to be much smaller (but plentiful). Overestimation of rain occurs in hail storms or when the RADAR beam intersects the freezing level in the upper atmosphere.

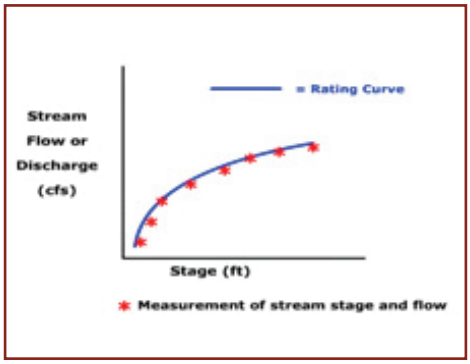
  Rain gages can also have inaccuracies. If gages are located too close to tall buildings or trees, or if the rain is accompanied by high winds, the gages will measure too low. They also need to be well maintained and winterized to prevent clogs from ice, snow, insects or debris.

  The type of precipitation falls, whether as rain, snow, sleet or freezing rain, will affect how much and when runoff will reach the stream. Any uncertainty in the type of precipitation will correlate to uncertainty in the river forecast.

Uncertainty Factors *(continued)*

- **Rating Curves** – This is the tool hydrologists use to translate flow forecasts into stages (Figure 3). These are not precise relationships and may change over time. This is a best fit line, and does not cover all data points. Extremely high flows may be above the curve.

Figure 3: Rating Curve



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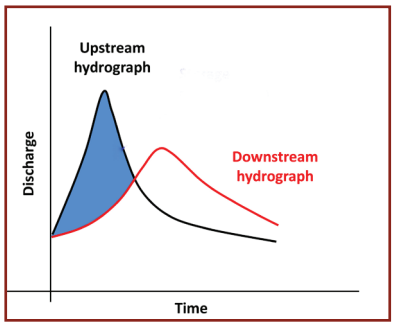
- **Assumptions of the hydrologic models** – Models attempt to replicate natural processes, but our current models have some basic assumptions that may at times prove to be too crude and limit their performance. The most significant assumption is that all precipitation is distributed evenly over the entire river basin over a six-hour period. If the rain does not occur in this fashion, the runoff may reach the stream faster or slower than predicted. There are improvements being developed in this area through more modern models that are able to utilize smaller portions of the basin and smaller time intervals to more accurately capture the natural processes.

- **Calibration** – The models are calibrated for each basin using historical data. As such, if a unique event occurs, the models may not be able to accurately account for it. The more historical data available (period of record), the more accurate the calibration.

- **Rainfall-Runoff Model** – Soil moisture is an important component of this model, yet very few measurements are available. Models usually estimate soil moisture and if the estimate is off, the amount of runoff expected from a rain event could be different.

- **Routing** – Moving flow downstream is done through a routing model (Figure 4). Generalizations are made on the amount of lag and attenuation that may not fit every case.

Figure 4: Routed Flood Wave



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The main stem Susquehanna River is more prone to ice jams and subsequent flooding than any other river east of the Rocky Mountains. *Photo: Severe ice jams at the Safe Harbor Dam, York and Lancaster Counties, PA.*

- **Snow Accumulation and Snowmelt** – The snow model only uses recent and forecast temperature data to estimate snow accumulation, snowmelt and the amount of water contained in the snowpack. Since there are many other unmodeled variables in nature, the contribution of runoff from snow could be uncertain.

- **Ice** – Ice on rivers change the shape of the river channel making rating curves ineffective. Ice formation and ice jams can also cause water to back up, resulting in sharp, quick river rises and even flooding. Ice is too chaotic and localized to model, but the hydrologist attempts to take it into account for the forecast.

Help Reduce Forecast Uncertainty

You can help increase the accuracy of river forecasts by sending the NWS your precipitation measurements. Ground-truth measurements of precipitation help NWS hydrologists get the most accurate picture of the distribution and amount of precipitation occurring in the basins. Precipitation measurements are always needed for the NWS river forecast process. If you are interested in sending us your rainfall observations, check out the volunteer program "CoCoRaHS" -- the Community Collaborative Rain, Hail and Snow Network. CoCoRaHS is a unique, non-profit, community-based, network of individual and family volunteers of all ages and backgrounds, who take daily measurements of rain, hail and snow in their backyards.

Credit: Henry Reges, CoCoRaHS

More info and training materials can be found on their website at: http://www.cocorahs.org

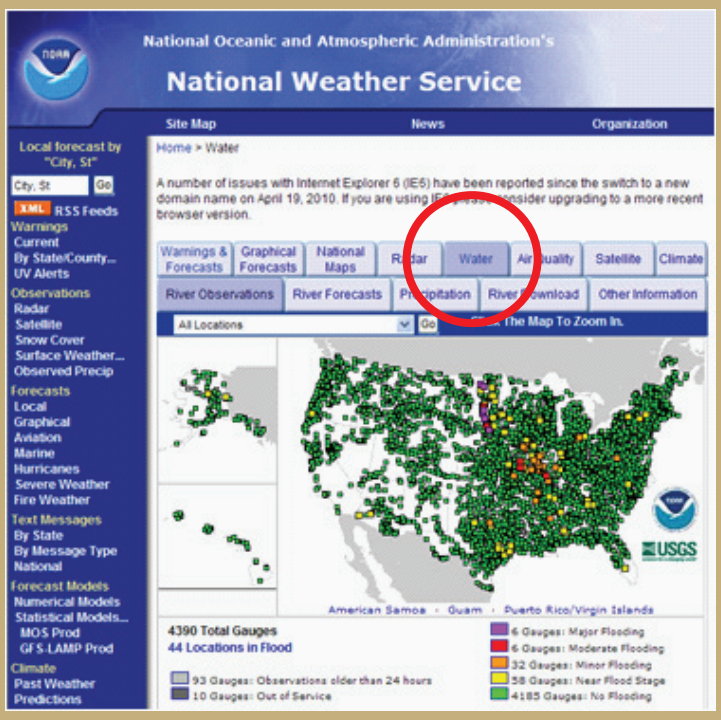
Stay on Top of Forecasts!

Knowing that there is uncertainty involved in river forecasting, what can you do?

Monitor the National Weather Service website for flood watches, flood warnings and river forecasts. Remember, this information is continually updated as new information is received. Forecasts will be more accurate closer to the actual event because more information is available to our hydrologists.

Know your potential for flooding and continually check our website for the latest forecasts, day and night -- http://weather.gov (click on the Water Tab).

For more information on the NWS's Advanced Hydrologic Prediction Services website, including help on how to interpret forecast graphics, see the toolbox located at: http://www.nws.noaa.gov/om/water/Ahps.shtml.



Uncertainty Factors *(continued)*

- **Reservoir Operations** – Water released from reservoirs contributes to river flows. The NWS works with the U.S. Army Corps of Engineers to coordinate and share information on releases as much as possible. But deviations from expected releases may produce inaccuracies in our forecasts.
- **Stream Gages** – The U.S. Geological Survey (USGS) operates and maintains the stream gage network. The accuracy of the actual USGS flow discharge measurements is usually within 5 percent of the true flow and sometimes less. Difficult hydrologic and other measurement conditions can at times introduce unavoidable errors as much as 15 to 20 percent depending on the severity of the condition.
- **Baseflow** – The portion of precipitation that does not flow directly into a stream as runoff seeps into the ground and slowly recharges the stream channel from underground. This baseflow is most uncertain when rain is occurring during the forecast period because it cannot be measured directly.

The NWS River Forecast Centers are undergoing a major system upgrade with their implementation of CHPS (Community Hydrologic Predictions System). With CHPS, more than one hydrologic model can be used and compared to help speed up the pace of scientific advancement and improve river forecast accuracy.

The Middle Atlantic River Forecast Center uses data from USGS stream gages to forecast river stages and flows in the Middle Atlantic Region. USGS field personnel are deployed to stream gage stations during periods of high water to compare stages with flows and help update and improve the Rating Curve.

Weather Trackers: Check Out Forecast Discussions

The NWS's Middle Atlantic River Forecast Center (MARFC) issues a text product written by its hydrometeorologist that provides insight into the factors in today's river forecast process and the level of confidence in those areas. This product is called the Hydrometeorological Discussion Product. Look for it on the MARFC website at http://weather.gov/marfc. It is issued every morning and updated as conditions change.

In addition, all NWS Weather Forecast Offices offer a similar text product they call the Area Forecast Discussion. Links are provided to the Area Forecast Discussion off each office website. The web addresses for the NWS Weather Forecast Offices serving the Middle Atlantic region are:

- Binghamton, NY http://weather.gov/bgm
- New York City, NY http://weather.gov/okx
- Central Pennsylvania, PA http://weather.gov/ctp
- Philadelphia/Mt Holly, NJ http://weather.gov/phi
- Baltimore/Washington, MD/VA http://weather.gov/lwx
- Roanoke, VA http://weather.gov/rnk
- Wakefield, VA http://weather.gov/akq

To learn more about hydrology, there are free online training modules available from The COMET Program at http://www.meted.ucar.edu/.

Sample Message under Hydrometeorological Discussion:

... A COLD FRONT BROUGHT SHOWERS AND THUNDERSTORMS TO PARTS OF THE MID ATLANTIC REGION OVER THE PAST 24 HOURS. THE HEAVIEST RAINFALL SINCE 12Z SUNDAY FELL ALONG THE MARYLAND/ PENNSYLVANIA BORDER INTO PARTS OF SOUTHEAST PENNSYLVANIA AND NORTHERN NEW JERSEY. VERY HEAVY RAIN FELL ACROSS THE LOWER SUSQUEHANNA RIVER BASIN WHICH PRODUCED SHARP RISES ON LOCAL STREAMS AND CREEKS...

For more information on the subject of uncertainty in river forecasts, visit our website at http://weather.gov/marfc or contact:

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Photo: Chemung River, New York
Credit: STCPRDB

Source: Stream Gaging and Flood Forecasting A Partnership of the U.S. Geological Survey and the National Weather Service