Mount Mansfield Stream Gages

Water Year 2014 report

U.S. Geological Survey
in cooperation with
Vermont Monitoring Cooperative

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Introduction

This is the annual data report for the U.S. Geological Survey (USGS) stream gages at Ranch Brook and West Branch near Stowe, Vermont for Water Year (WY) 2014 (October 2013 through September 2014). The two gages were established in September 2000, and have been operated continuously by USGS since that time (Wemple et al., 2007). Historic and near real-time flow data are available on the USGS website (addresses given at end of this report). The gaging was designed as a paired watershed study, with Ranch Brook (9.6 km^2) as the forested control watershed, and West Branch (11.7 km^2) as the developed watershed (cover photo). West Branch contains nearly the entire expanse of Stowe Mountain Resort. Though the resort was well-established when the gaging began, it underwent a significant expansion during the course of the study. This report interprets the WY14 streamflows in the context of the full 14-year record.

The gages are jointly funded through a cooperative agreement between the USGS and Vermont Monitoring Cooperative. They provide needed information on mountain hydrology in Vermont, and how mountain landscapes respond to development and extreme events. To our knowledge these are still the only gaged watersheds at a ski resort. The gages have supported projects on snow hydrology and water quality by University of Vermont, Sterling College, Vermont ANR, and others. In particular, Beverley Wemple and students at University of Vermont have used the gaging as a base for student projects and hands-on learning, and to attract additional funding for value-added research.

Results

WY2014 was a relatively tranquil year hydrologically, though there was one notable peak from a rain-on-snow event on April 15 (Figure 1). Overall, runoff was less than the long-term average. (Fig. 2).

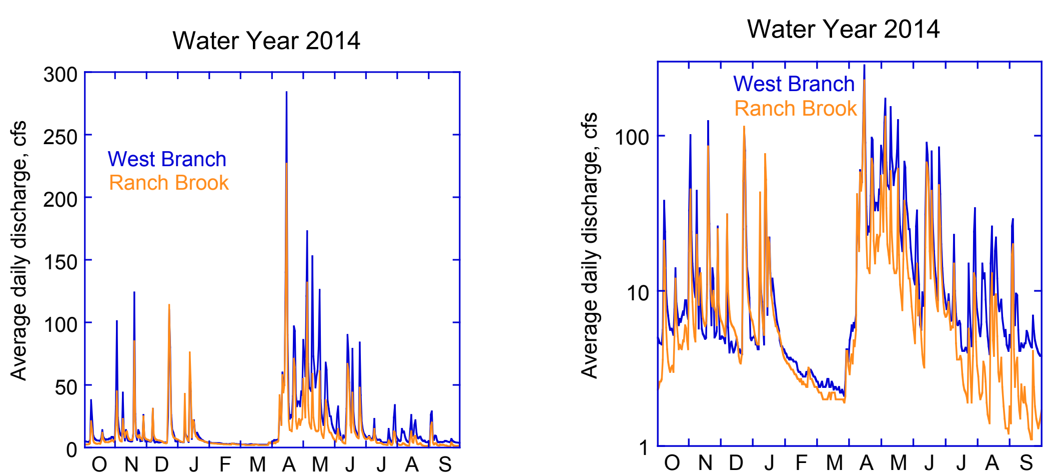

Figure 1. Streamflow at West Branch and Ranch Brook gages for Water Year 2014 (October 2012 through September 2013) in linear (left) and log (right) scales. The log scale plot illustrates the higher sustained base flow levels at West Branch.

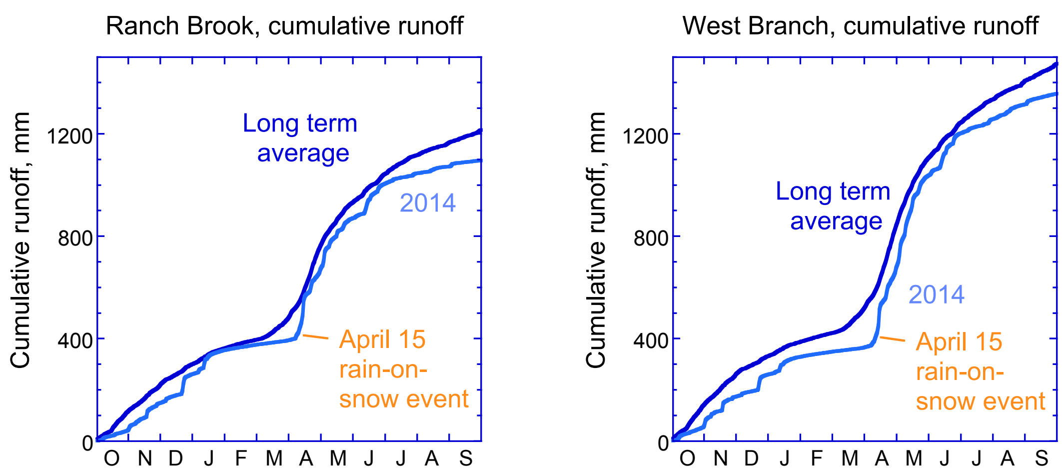

Figure 2. Cumulative runoff for Water Year 2014 (light blue lines) at Ranch Brook (left) and West Branch (right) plotted on the long-term (2001-2014) average at each site (dark blue lines).

Water Year 2014 started off with a dry fall and played "catch up" all year, but in the end fell below average for total runoff. West Branch fell further behind than Ranch Brook due to snowmaking withdrawals in the late fall and first part of winter. Rain and thaws in January brought both sites closer to average. A late snowmelt accompanied by a large rain-on-snow event on April 15 helped bring both sites to near average by the start of summer. But summer 2014 was dry in northern Vermont, leading to a steeper than average summer baseflow recession and an overall below-average flow year. The April 15 event was quite noteworthy as the 4th highest peak at Ranch Brook and 5th highest peak at West Branch over the 14 years of record.

Throughout the 14 years of streamflow monitoring, West Branch has consistently yielded higher runoff (flow normalized to watershed area) than Ranch Brook (Wemple et al., 2007) (Figures 3 and 4). Over the long-term, the average difference has been 21% greater runoff at West Branch. In Water Year 2014 the differential was slightly above average at 24% (Figure 4). Greater runoff at West Branch is what we would expect from the development; creation of impervious surfaces (parking lots, buildings), compacted soils (ski trail maintenance), and direct discharge of stormwater, tend to increase surface runoff directly to streams at the expense of groundwater recharge, resulting in higher streamflow. Also, removal of trees for trails and development means less water demand by the forest, leaving more water available to run off. Because the ski resort was already in place when the gaging started, we cannot quantify its effect on hydrology. But the high magnitude of the differential suggests that some part of the difference may be natural. For example, there could be greater water input at West Branch due to different precipitation patterns in the two watersheds, snow redistribution, or groundwater input from outside the basin via bedrock fractures.

Although annual runoff is consistently greater at West Branch, the relative difference varies greatly from year to year (Figure 4). The runoff differential peaks during the snowmelt period in April and May (Figure 3, right), partly as a consequence of the enhanced snowpack from machine-made snow, and the prolonged melt of skier-compacted snow. The low to negative differentials in late fall and early winter result from historic water extraction from West Branch for snowmaking. As yet, we have not been able to make a definitive assessment of the ski resort build-out on runoff. The assessment has been confounded by the construction of a large snowmaking storage pond, increased snowmaking, irrigation of the new golf course, and a new stormwater drainage system for the development.

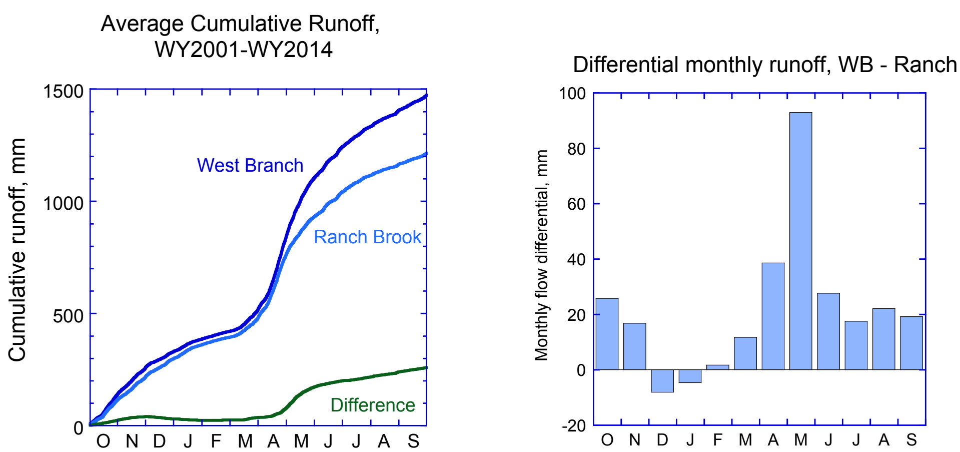

Figure 3. Long-term (Water Years 2001 to 2014) average annual cumulative runoff at West Branch and Ranch Brook (left) and differential by month (right).

A striking aspect of the flow record is the increasing frequency and magnitude of high flow events. Of the 14 years of record, the six highest peak flows at West Branch and four highest peak flows at Ranch Brook have occurred in just the past five years (Figure 5). In 2011, two of the highest peaks of record occurred. The April 26-27 event was widespread and triggered the prolonged flood stage on Lake Champlain. The August 28-29 event was tropical storm Irene, which caused widespread flooding throughout most of Vermont. Surprisingly, however, it is not always the headline-making storms that cause the highest peak flows on Mt. Mansfield. The highest peaks of record at both gages occurred in 2010, from a different storm at each gage. These storms were fairly isolated to the mountain, and were likely stalled storm cells. It is common for a storm to have much greater impact in one watershed than the other in these two adjacent watersheds. In fact, the peak annual flows at each gage were only coincident (i.e. from the same storm) in 7 of the 14 years of record (Figure 6).

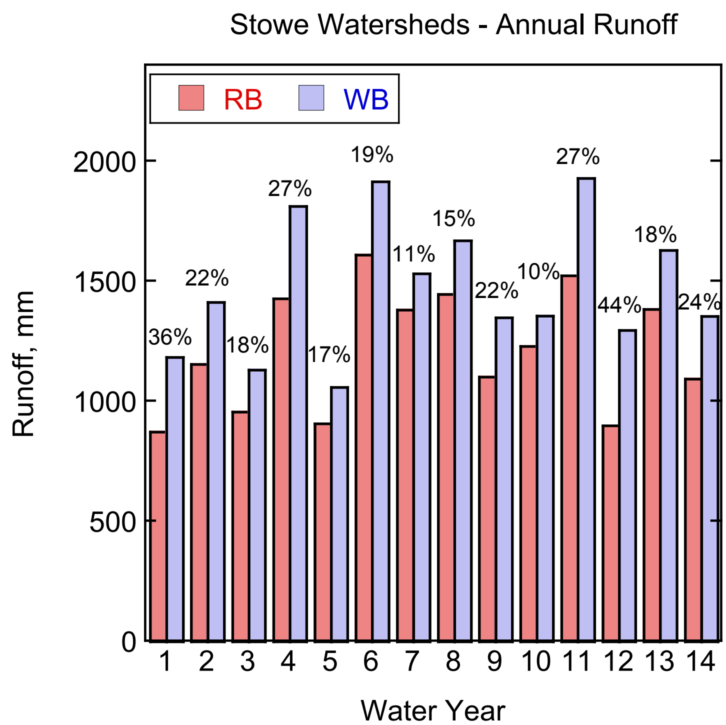

Figure 4. Annual runoff in mm at West Branch (WB) and Ranch Brook (RB) for the duration of study though the present report year. Percentage of greater runoff at WB relative to RB is given over each pair of bars.

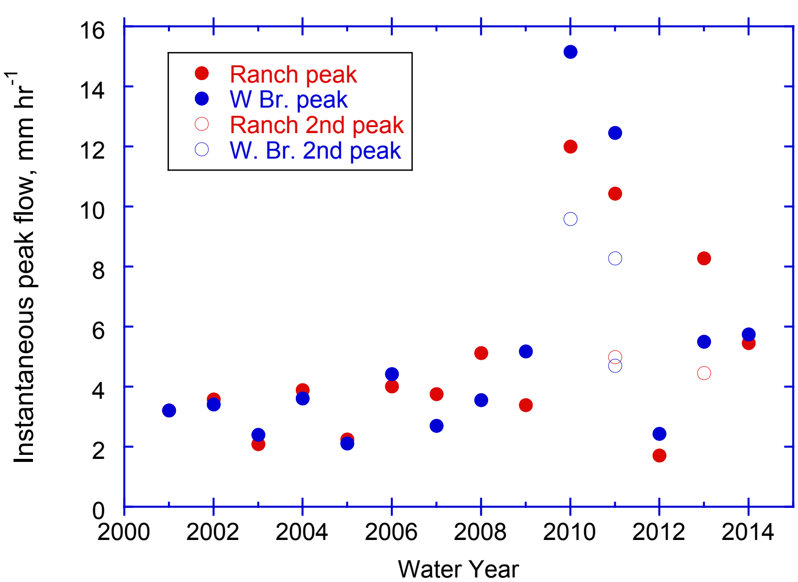

Figure 5. Peak flow for each water year (2001 to 2014) at West Branch and Ranch Brook gages, as well as all other peak flows exceeding 4 mm hr^{-1}.

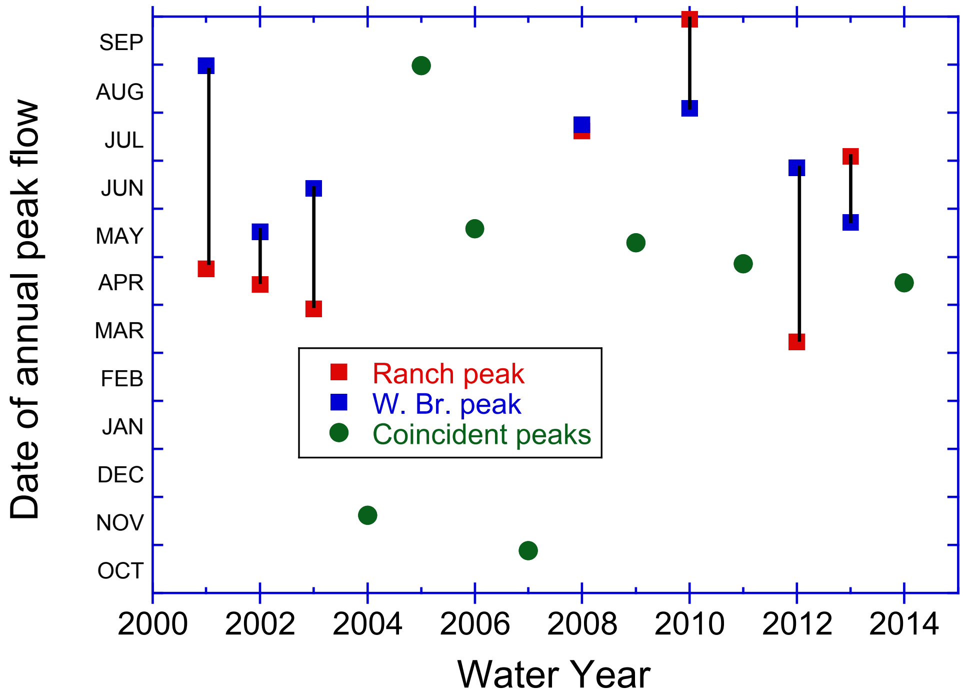

Figure 6. Dates of annual peak flow at West Branch and Ranch Brook gages. Line segments connect dates for same year when peaks fell on different days.

The other aspect of the flow record worth noting is the high magnitude of many of the peak flows. Specific discharge rates of 5 mm hr^{-1} are extremely high for Vermont, yet these have been happening nearly every year in the second half of the record, and some peaks have exceeded 10 mm hr^{-1}. For comparison, the highest flow since 1991 at a similarly-sized high-elevation watershed in northeastern Vermont (W-3 at Sleepers River) was 6.6 mm hr^{-1}. The high flow in general and unpredictable peak flows in particular at the high-elevation setting of Mt. Mansfield underscore the need to know more about hydrology in our mountain areas and the importance of continued monitoring.

West Branch data are accessible at
http://waterdata.usgs.gov/vt/nwis/uv?site_no=04288225.
Ranch Brook data are accessible at
http://waterdata.usgs.gov/vt/nwis/uv?site_no=04288230.

References

Wemple B, Shanley J, Denner J, Ross D, Mills K., 2007. Hydrology and water quality in two mountain basins of the northeastern US: assessing baseline conditions and effects of ski area development. Hydrological Processes 21(12):1639-1650.