Annual Report – Year 2003

Subsurface Flow Processes in Honey Creek
Work supported by the San Antonio Water System

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In 2002, The San Antonio Water System provided $125,000 to Texas A&M University to examine the hydrologic influence of cedar on the water recharge and streamflow in the Edward Plateau region of Texas. This support is being used to enhance ongoing efforts at the Honey Creek Study Area. Two primary focus areas have been that of (1) understanding flow and chemistry of the *Demonstration Watershed* and (2) understanding water chemistry of the springs feeding into Honey Creek. In addition, SAWS support has been used to complement our large plot rainfall simulation studies. The rainfall simulation work on Honey Creek is just now getting implemented and will not be summarized in this report. Support provided by SAWS is complemented by funding from the National Science Foundation and support from Texas A&M University. In addition, support in the way of equipment and collaboration has been provided by the Natural Resource Conservation Service (NRCS). The *Demonstration Watershed* was established by the NRCS who installed a flume and a weather station and provided support for clearing of the juniper. Weather and streamflow data collected by the NRCS have been generously shared for the purpose of this study. The Honey Creek State Natural Area is managed by the Texas Parks and Wildlife and we acknowledge their support and collaboration in this study. Analysis and interpretation of these data have been accomplished by Yun Huang, a Ph.D. student at Texas A&M. *These data are preliminary and should not be distributed outside of SAWS.*

This report summarizes the Honey Creek Experimental Watershed (HCEW) precipitation and runoff data from 26 August 1999 to 26 Aug 2003, a four-year period with 2 year (26 August 1999 to 25 August 2001) being pretreatment and another 2 year posttreatment. More recent data have not been incorporated for the sake of balanced time series analysis. In the data set, we have two-day's missing data, 30-31 August 2002. The daily values of those 2 days have been fitted using average values of 29 August and 1 September 2002.

SITE CHARACTERIZATION

The Honey Creek Experimental Watershed is located at the headwater area of a tributary of Honey Creek, which is part of Honey Creek State Natural Area in western Comal County of Texas. An H-flume has been installed to monitor hourly streamflow from that watershed. The upstream drainage area is about 37 ha. The elevation of the outlet is estimated to be 369 msl from U. S. Geological Survey 7.5-minute quadrangle map. The land is juniper dominated with gentle to steep topography.

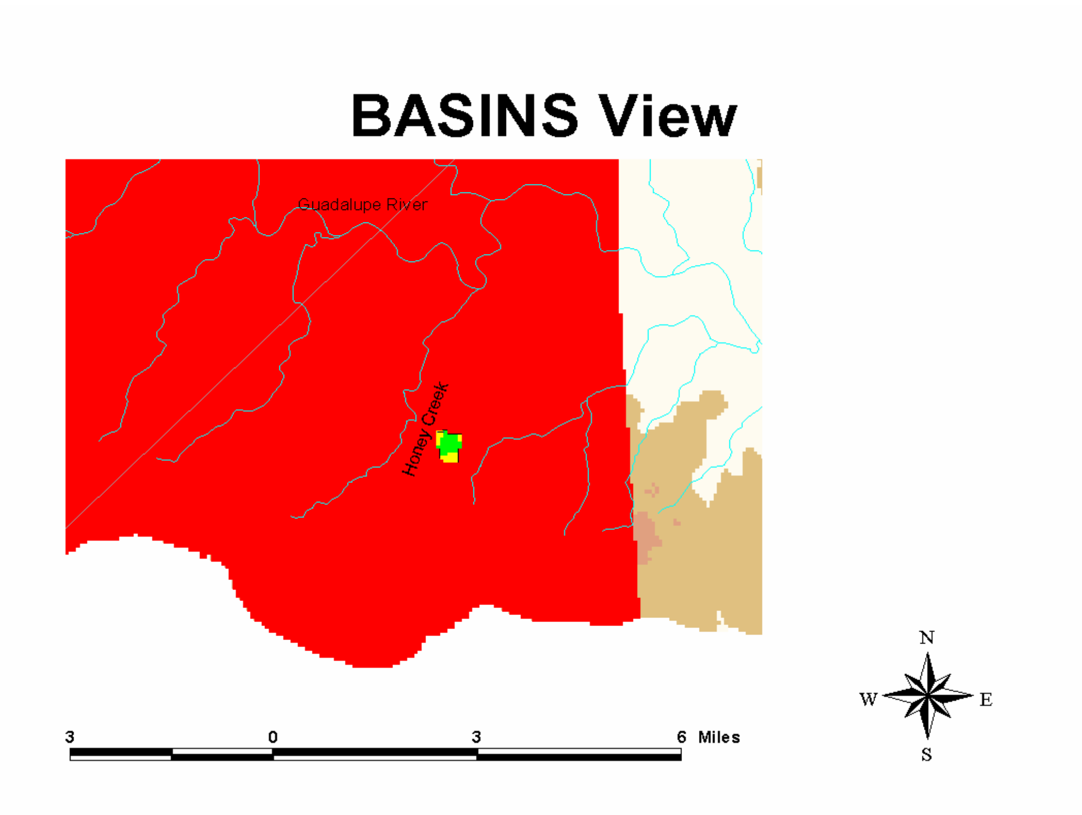

Figure 1. Honey Creek Experimental Watershed location. Honey Creek Experimental Watershed (yellow plus green inset) is located in the Upper Guadalupe Basin (HUC 12100201) in western Comal County of Texas. This is the BASINS view in SWAT model by 30 m x 30 m resolution DEM.

PRECIPITATION ANALYSIS

Daily Precipitation

The maximum daily precipitation during the 4 years was 142 mm, which occurred on 14 November 2001. The annual daily maximums for 3 complete years are listed in the table 1.

Table 1. Annual daily precipitation maximum at HCEW

Date	Year	Amount (mm)
1 Nov	2000	79
14 Nov	2001	142
1 Jul	2002	105

Monthly Precipitation

The maximum monthly precipitation was 327 mm, which occurred in July 2002. The average monthly precipitation at Honey Creek is shown in figure 2.

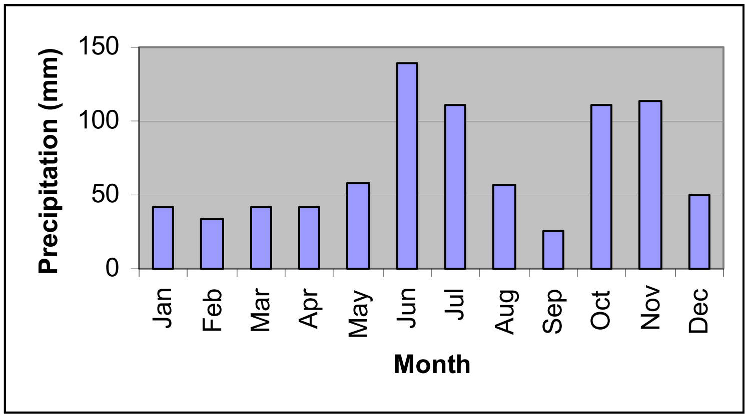

Figure 2. Average monthly precipitation from August1999 to August 2003

Annual Precipitation

The annual precipitation analysis is based on record year instead of calendar year. The average annual precipitation is 825 mm, with minimum 433 mm and maximum 1106 mm. The data is summarized in table 2.

Table 2. Average annual precipitation at HCEW

Duration	Amount (mm)
Sept 99 to Aug 00	433
Sept 00 to Aug 01	1018
Sept 01 to Aug 02	1106
Sept 02 to Aug 03	744

RUNOFF ANALYSIS

Daily Runoff

The maximum daily runoff during the 4 years was 28 mm, which occurred on 1 July 2002. The annual daily maximums for 3 complete years are listed in the table 3.

Table 3. Annual daily runoff maximum at HCEW

Date	Year	Amount (mm)
4 Nov	2000	6
14 Nov	2001	23
1 Jul	2002	28

Monthly Runoff

The maximum monthly runoff was 112 mm, which occurred in July 2002, not surprisingly. The average monthly runoff at Honey Creek is shown in figure 3.

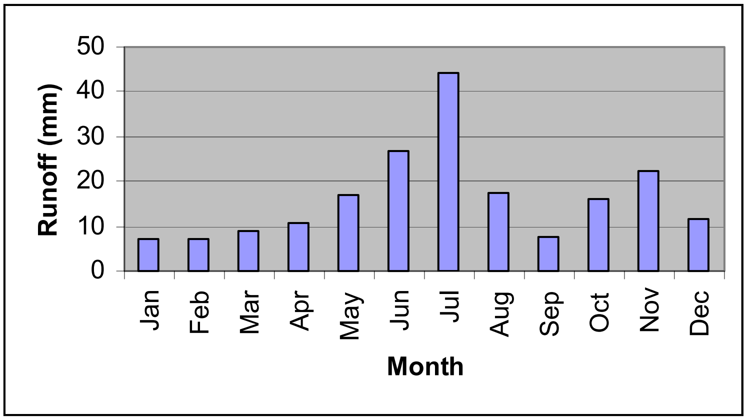

Figure 3. Average monthly runoff from August1999 to August 2003

Annual Runoff

As the same for annual precipitation analysis, the annual runoff analysis is based on record year instead of calendar year. The average annual runoff is 825 mm, with minimum 433 mm and maximum 1106 mm. The data is summarized in table 4.

Table 4. Annual runoff at HCEW

Duration	Amount (mm)
Sept 99 to Aug 00	27
Sept 00 to Aug 01	121
Sept 01 to Aug 02	314
Sept 02 to Aug 03	324

Annual Precipitation Runoff Comparison

As a comparison, the data in table 2 and 4 is graphed blow.

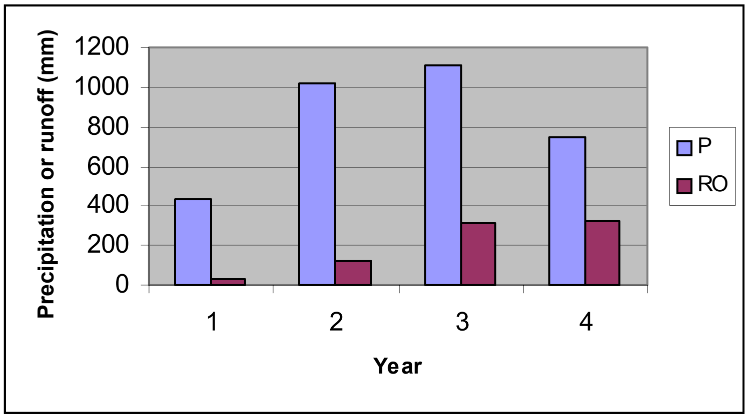

Figure 4. Annual precipitation and runoff at Honey Creek Experimental Watershed. Year 1 is the period from September 1999 to August 2000.

PRECIPITATION-RUNOFF ANALYSIS

Precipitation-runoff analysis is meant to evaluate the watershed response after vegetation removal. We designated 26 August 2001 as the treatment date since part of juniper trees were removed from the watershed in the summer of 2001. (We would like to have more data on the exact dates when juniper trees were removed, what percent were removed, what the selection criteria for removal were). The analysis has been done for pretreatment period (26 August 1999 to 25 August 2001) and posttreatment period (26 August 2001 to 28 August 2003).

Precipitation-runoff analysis is done on the daily, weekly, and monthly basis (Figure 5 - 10). The daily-based analysis is summarized in table 5. The watershed response for pretreatment and posttreatment period was 0.11 and 0.32, respectively. Weekly or monthly regression model could better evaluate the aggregate effect of the precipitation on runoff. However, the simple linear model did not provide good fit for either of them. A comparison is shown in table 6.

However, the data indicates that water yield from posttreatment period was higher than that from pretreatment period. This could be due to the woody vegetation removal, or the increased stimulus, or the combination of two.

Table 5. Daily-based precipitation-runoff at HCEW

Period	Duration	Precip P (mm)	Runoff Q (mm)	Q/P	R-square
Pre-	(8/26/99 to 8/25/01)	1285	137	0.11	0.32
Post-	(8/26/01 to 8/28/03)	2018	651	0.32	0.62
Total		3303	788	0.24	0.51

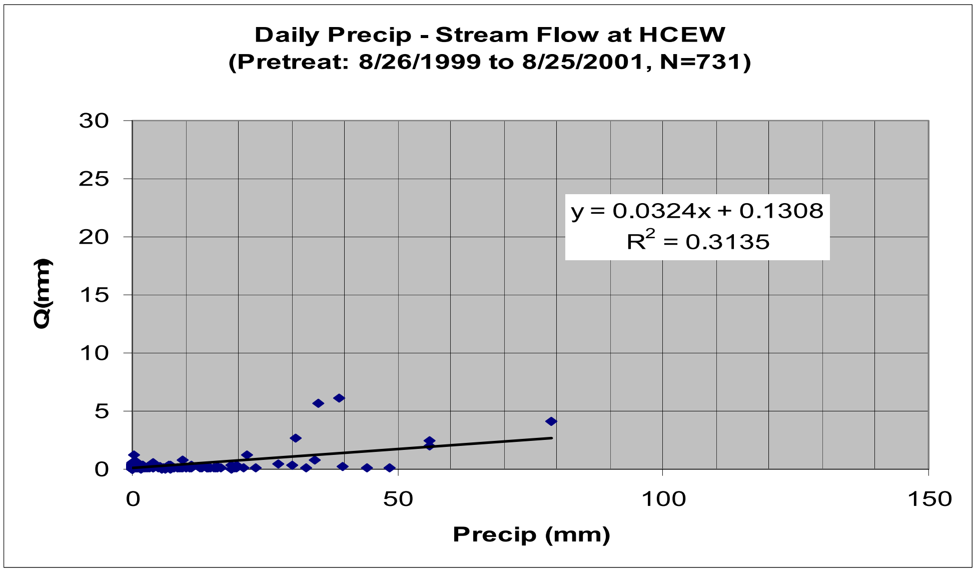

Figure 5. Regression of daily runoff against daily precipitation for the pretreatment period (from 26 August 1999 to 25 August 2001)

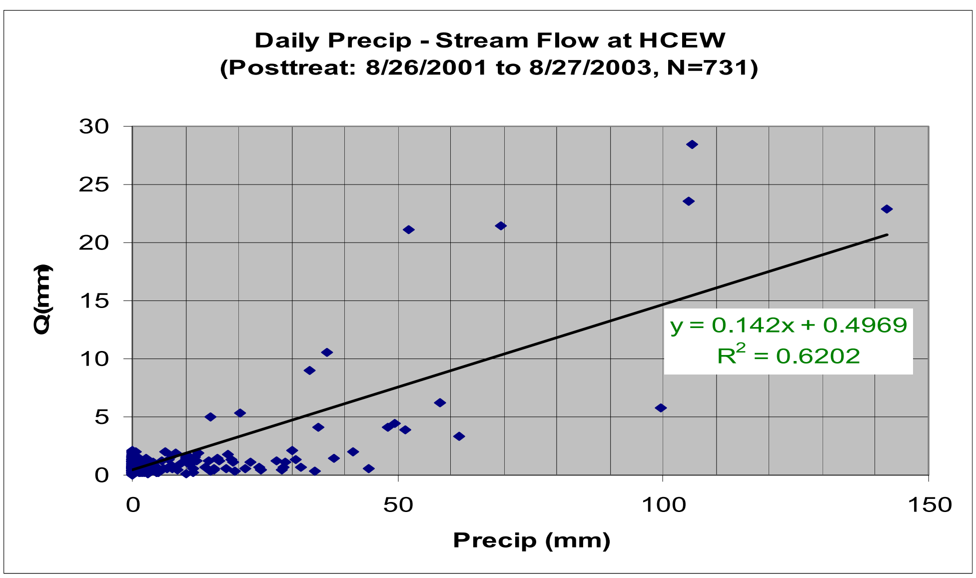

Figure 6. Regression of daily runoff against daily precipitation for the pretreatment period (from 26 August 2001 to 27 August 2003)

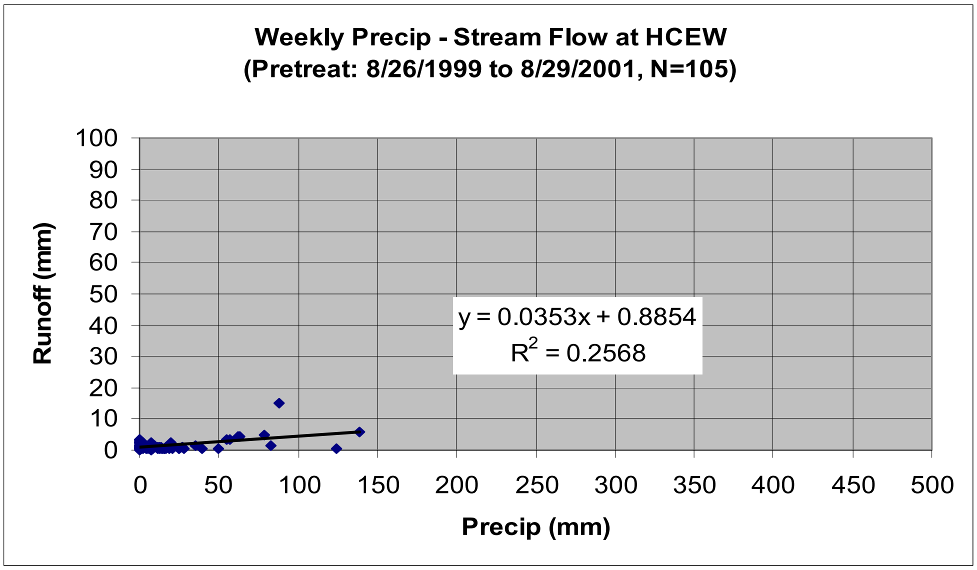

Figure 7. Regression of weekly runoff against weekly precipitation for the pretreatment period (from 26 August 1999 to 29 August 2001)

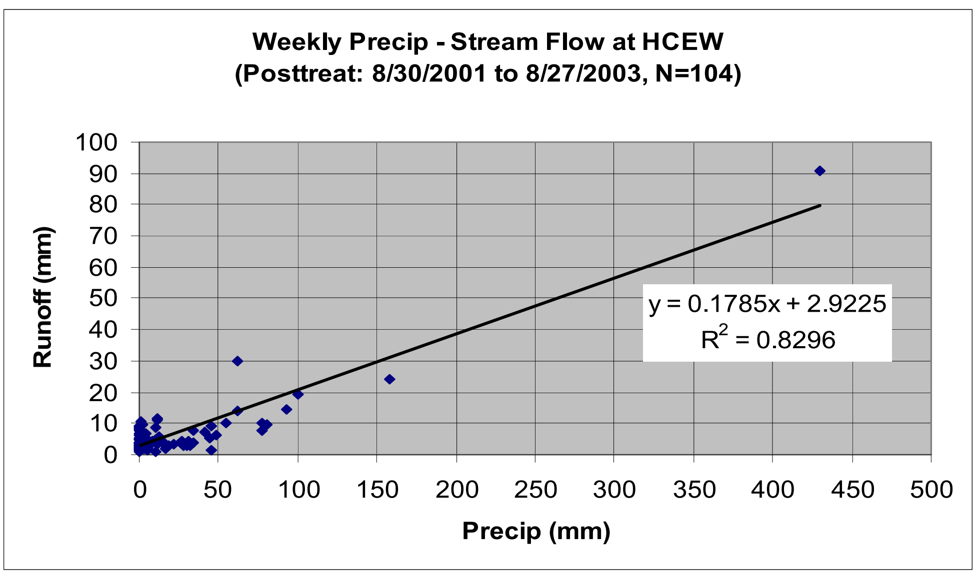

Figure 8. Regression of weekly runoff against weekly precipitation for the pretreatment period (from 26 August 2001 to 27 August 2003)

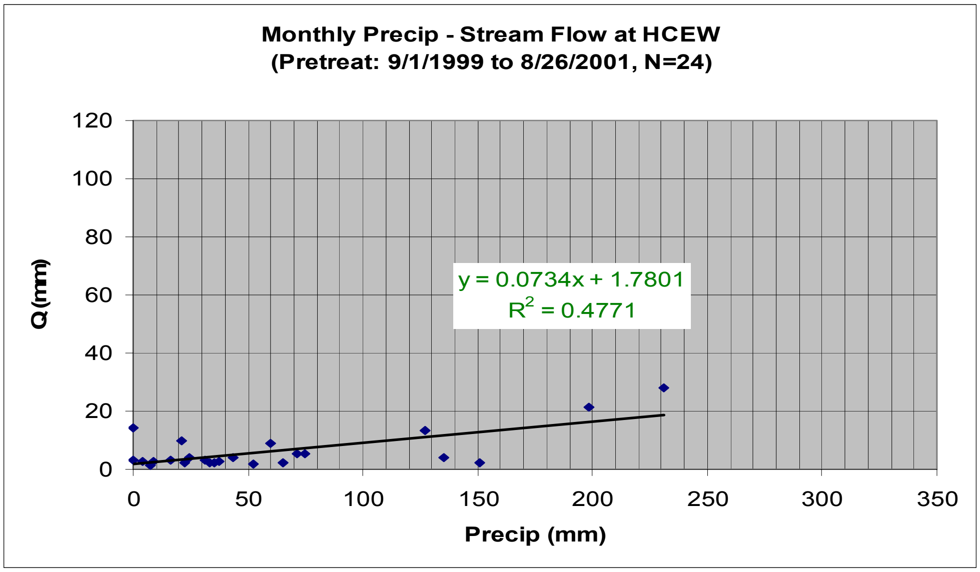

Figure 9. Regression of monthly runoff against monthly precipitation for the pretreatment period (from 1 September 1999 to 26 August 2001)

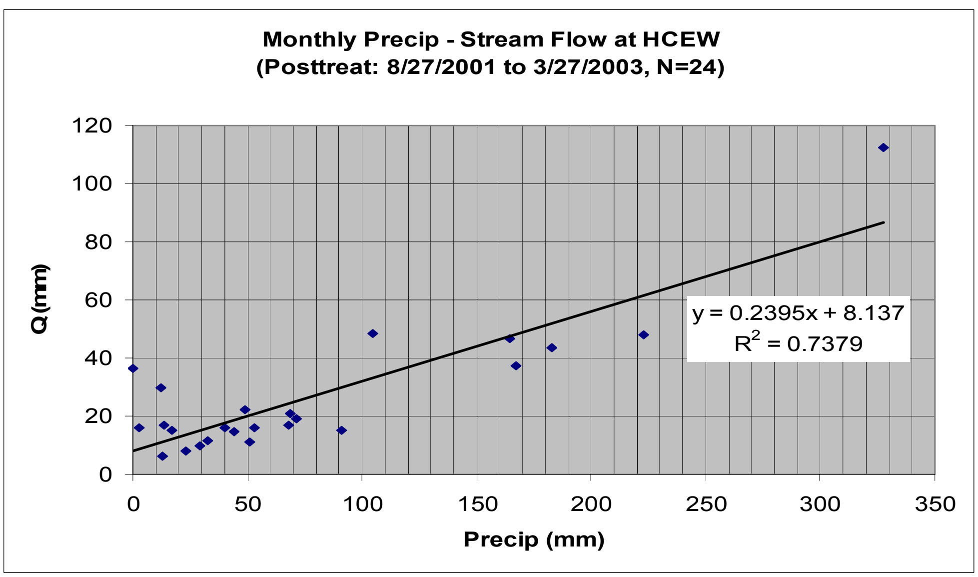

Figure 10. Regression of weekly runoff against weekly precipitation for the pretreatment period (from 27 August 2001 to 27 August 2003)

Table 6. Daily, weekly, and monthly analysis comparison

Analysis	Total	Pre-treat	Post-treat
Period	(8/26/199 to 8/28/2003)	(8/26/1999 to 8/25/2001)	(8/26/2001 to 8/28/2003)
Daily	$y = 0.1154x + 0.2779$ $R^2 = 0.5057$	$y = 0.0324x + 0.1308$ $R^2 = 0.3135$	$y = 0.142x + 0.4969$ $R^2 = 0.6202$
Weekly	$y = 0.1516x + 1.3694$ $R^2 = 0.6545$	$y = 0.0353x + 0.8854$ $R^2 = 0.2568$	$y = 0.1785x + 2.9225$ $R^2 = 0.8296$
Monthly	$y = 0.1907x + 3.2943$ $R^2 = 0.5045$	$y = 0.0734x + 1.7801$ $R^2 = 0.4771$	$y = 0.2395x + 8.137$ $R^2 = 0.7379$

INDIVIDUAL EVENT ANALYSIS

Four individual events from each observation year were selected for hydrograph analysis. The four events selected were: 8-Jun-00, 20-May-01, 6-Oct-02, and 12-Jun-03. In the following hyetographs and hydrographs (Figure 11-18), zero hour refers to the starting time of appreciable amount of precipitation.

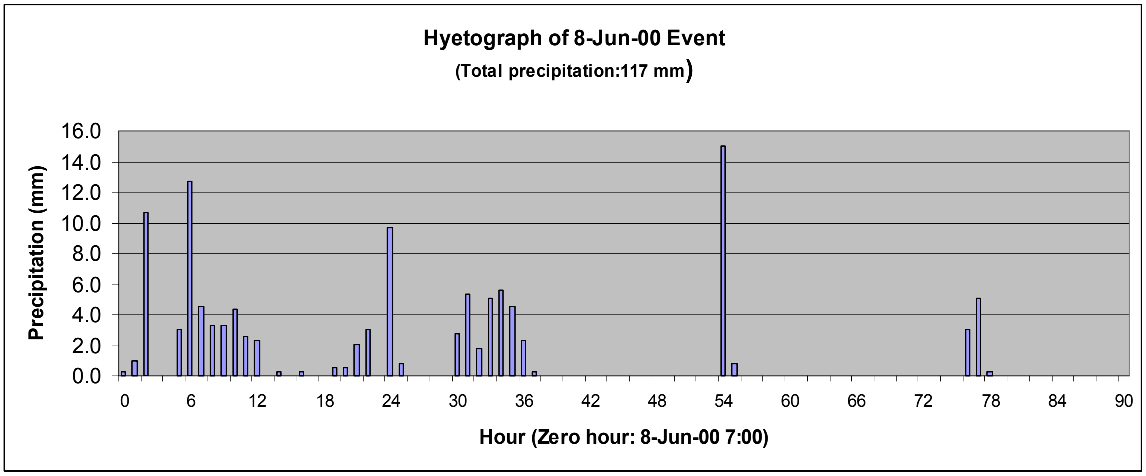

Figure 11. Hyetograph of 8 June 2000 event. The total amount of precipitation over this period was 117 mm.

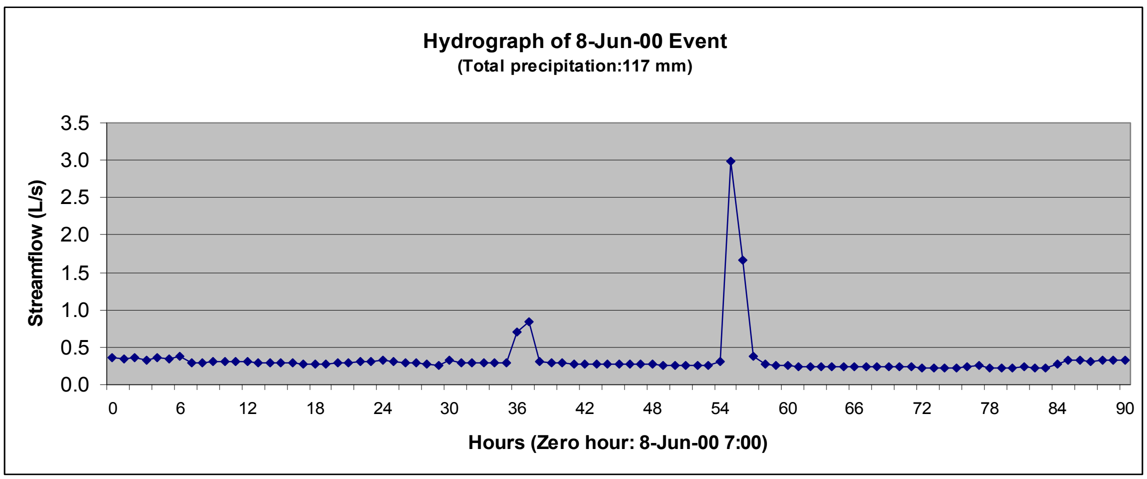

Figure 12. Hydrograph of 8 June 2000 event.

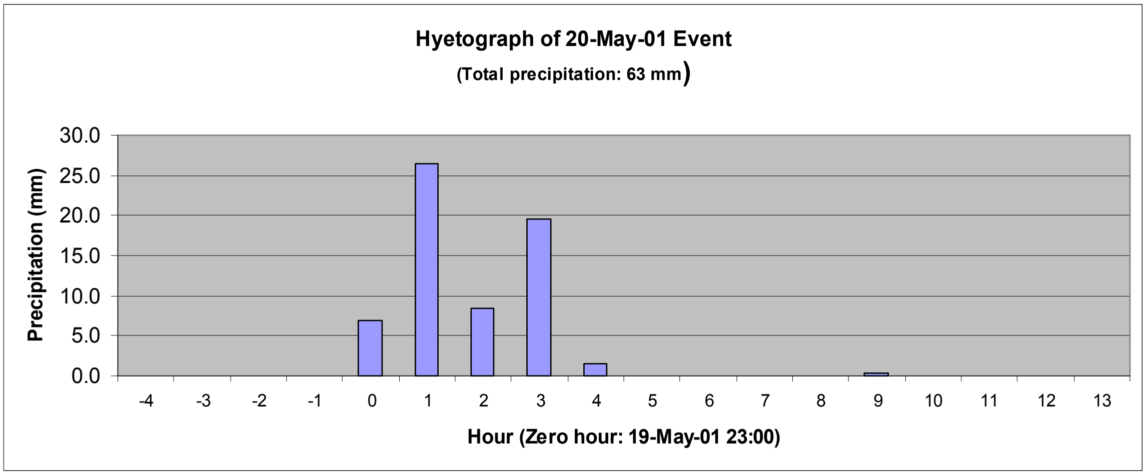

Figure 13. Hyetograph of 20 May 2001 event. The total amount of precipitation over this period was 63 mm.

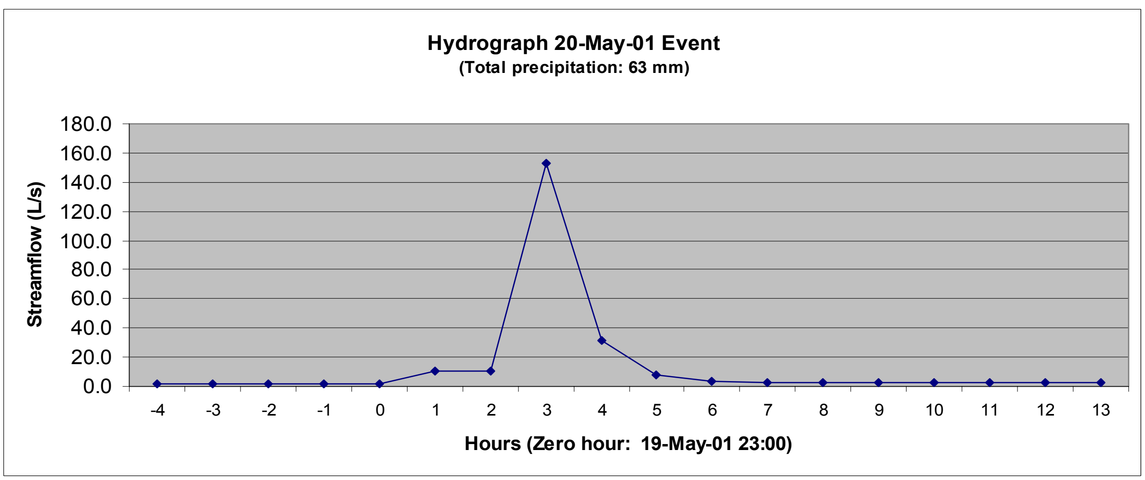

Figure 12. Hydrograph of 20 May 2001 event.

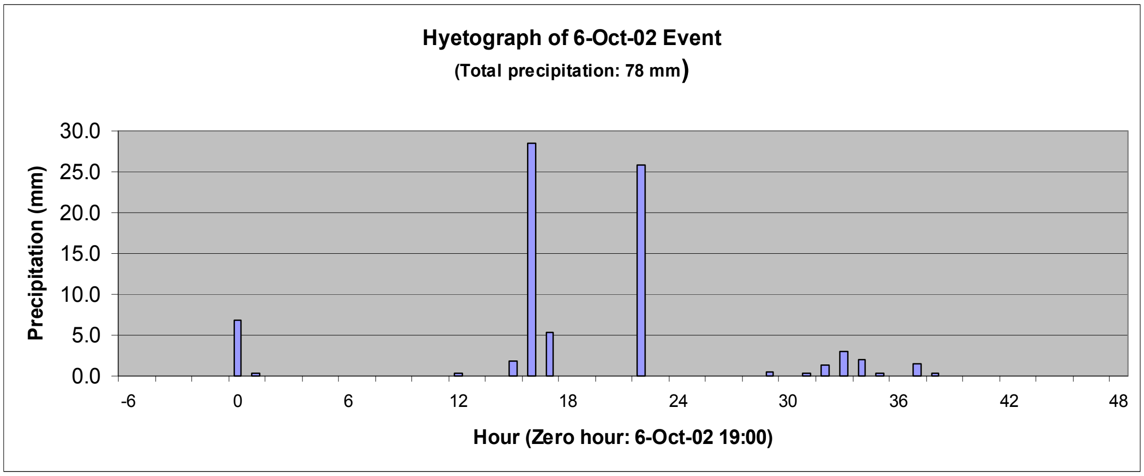

Figure 15. Hyetograph of 6 October 2002 event. The total amount of precipitation over this period was 78 mm.

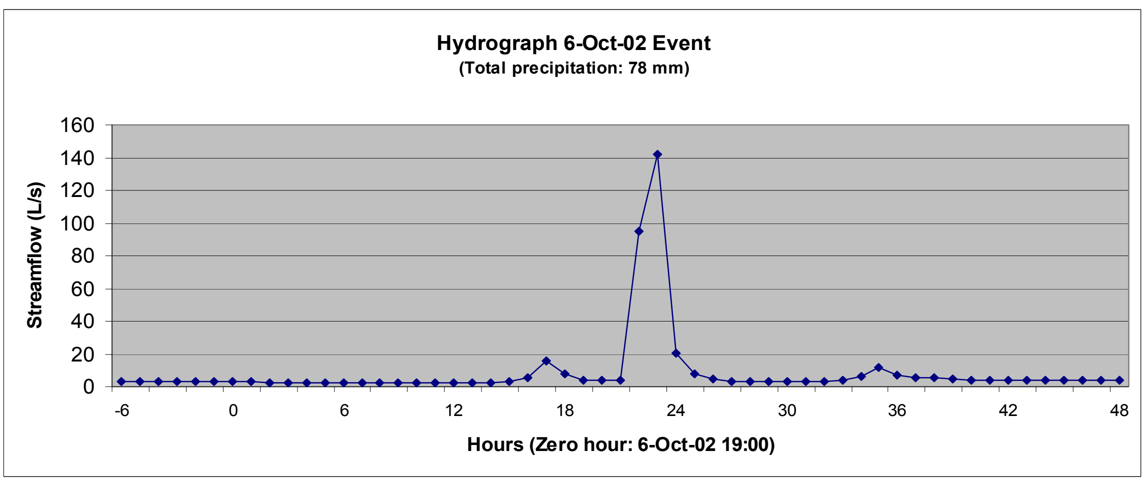

Figure 16. Hydrograph of 6 October 2002 event.

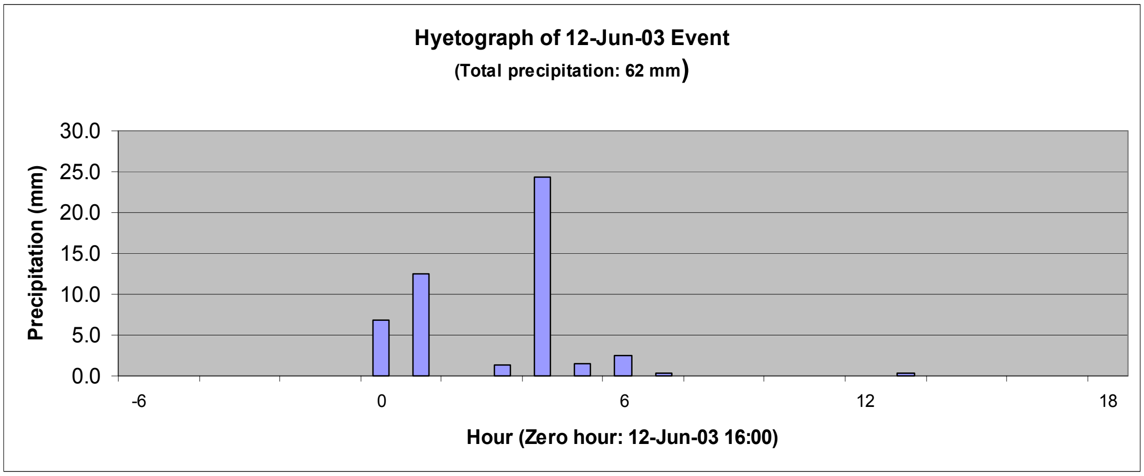

Figure 15. Hyetograph of 12 June 2003 event. The total amount of precipitation over this period was 78 mm.

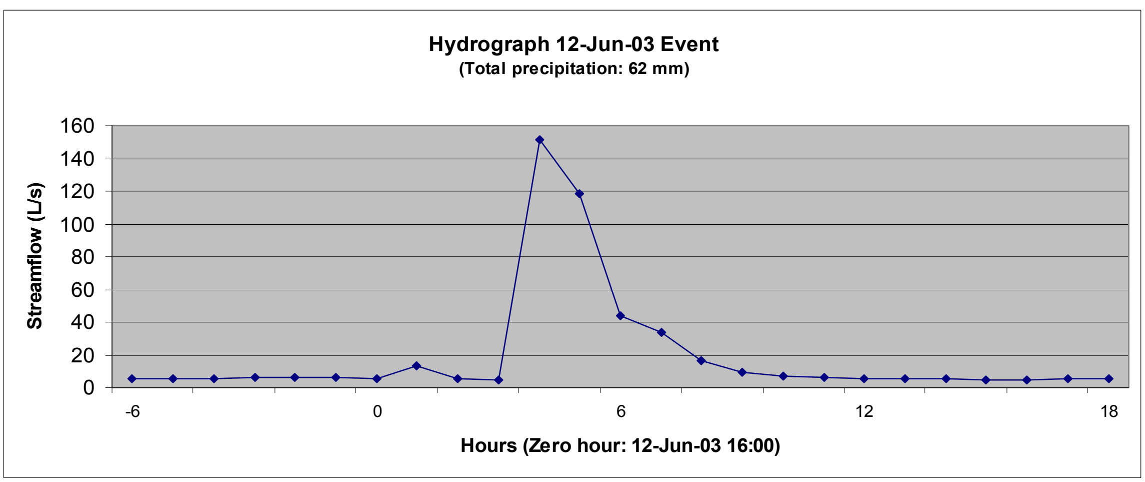

Figure 18. Hydrograph of 12 June 2003 event.

Most precipitation events produced flash runoff in the watershed, indicating runoff generation was from fast Horton overland flow or rapid subsurface flow.

STREAM CHEMICAL ANALYSIS

Stream sampling and monitoring was done on the monthly basis for evaluating the flow regime connection between upland watershed and bottomland creek. The pH, electrical conductivity, temperature, and isotopic composition of different locations of the creek, the main springs feeding the creek, and the upland experimental watershed site have been conducted.

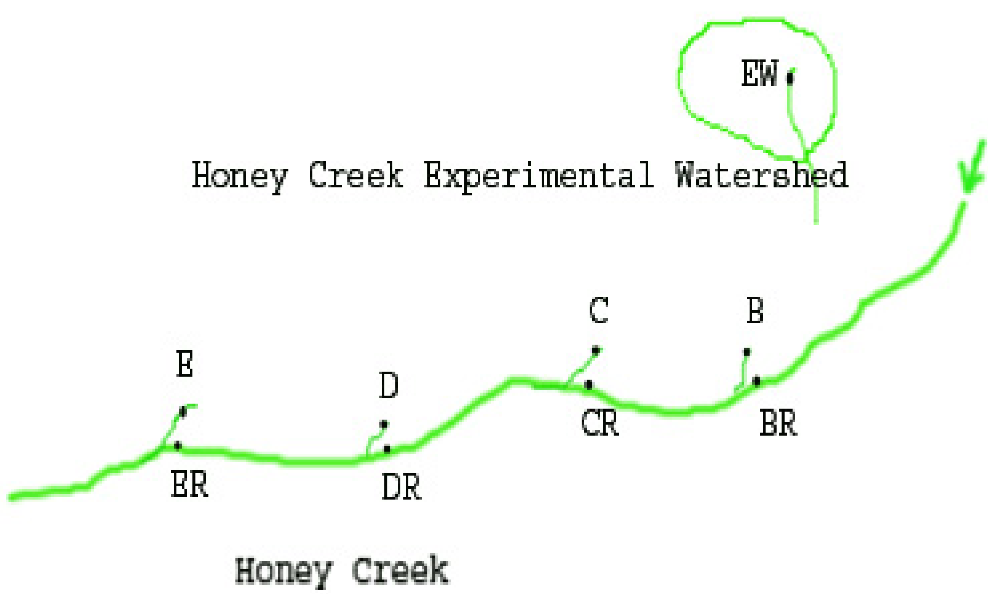

Figure 19. Sampling location at Honey Creek. B, C, D, and E indicates spring sampling location while BR, CR, DR, and ER indicating upstream creek sampling points. EW indicates upland watershed.

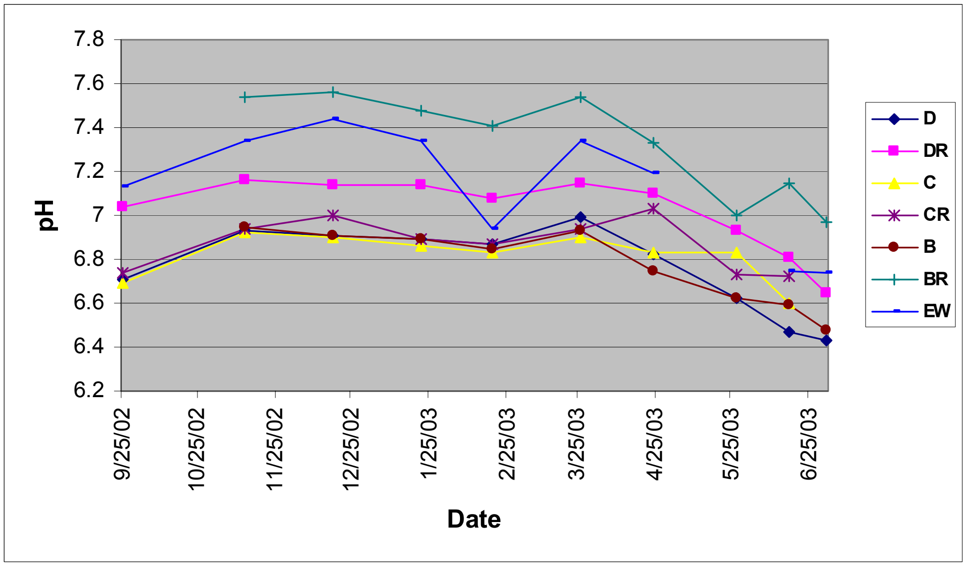

Figure 20. Monthly variation of pH at the sampling locations. The pH is well buffered by carbonate-bicarbonate system.

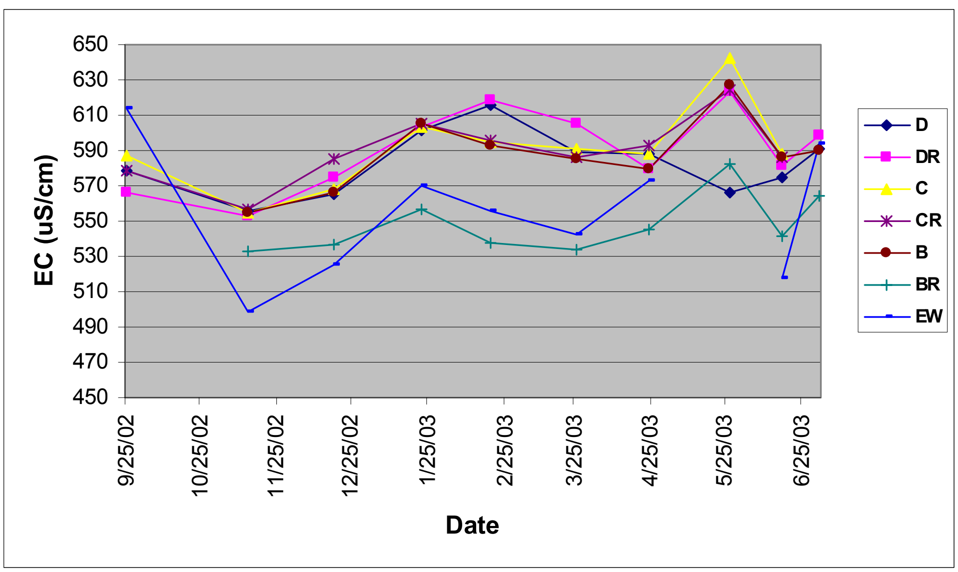

Figure 21. Monthly variation of electrical conductivity (EC) at the sampling locations. The EC reflects the total dissolved ions in the water.

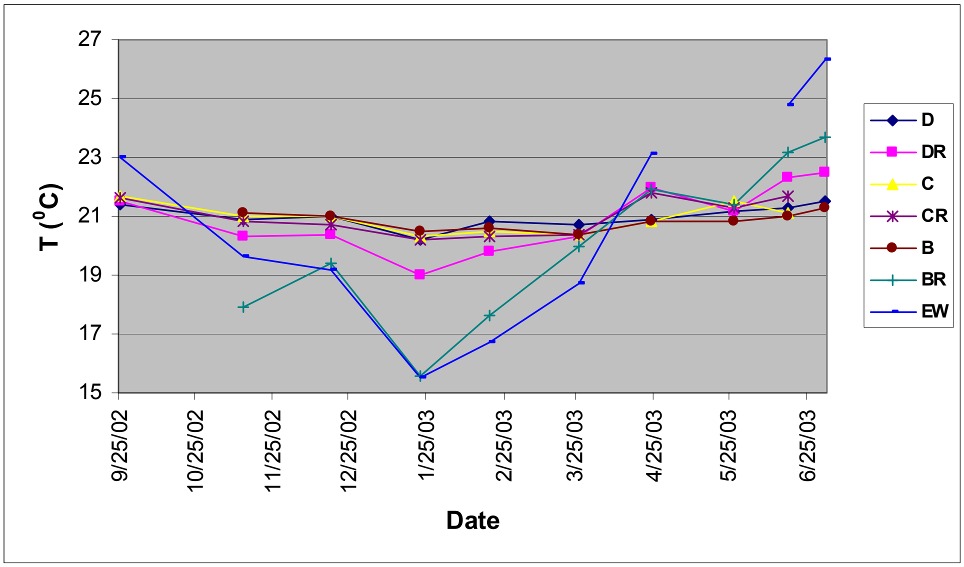

Figure 22. Monthly variation of water temperature at the sampling locations.

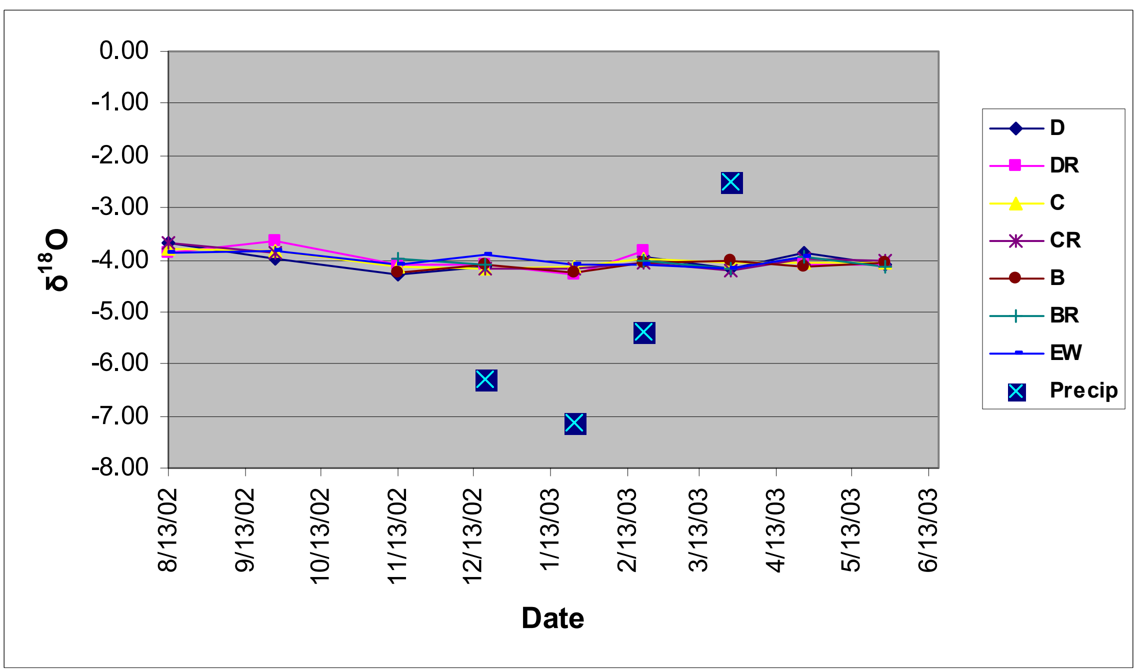

Figure 23. Monthly variation of $\delta^{18}O$ at the sampling locations.

The preliminary conclusions that we can draw from stream chemical analysis are:

1. The pH, electrical conductivity, and temperature variation from 3 springs were very close, indicating probable common water source for the springs.
2. The intra-annual variation of temperature of the springs was very small, indicating either (1) the flow was from minute fracture or seepage face instead of conduit flow, or (2) the flow was from a large water body.
3. The isotopic composition of rainfall samples was significantly different from that of the creek, spring, and upland experimental watershed samples, indicating water sources were not tightly coupled with current precipitation.

ISOTOPE HYDROGRAPH SEPARATION

Two component mixing model was employed for hydrograph separation. The approach provides temporal origin of runoff event sources.

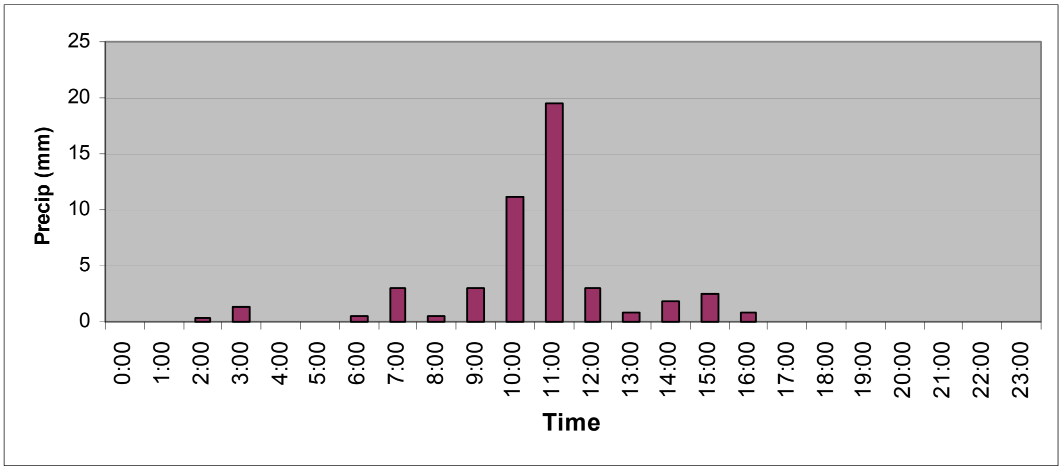

Figure 24. Hourly precipitation distribution of 20 February 2003

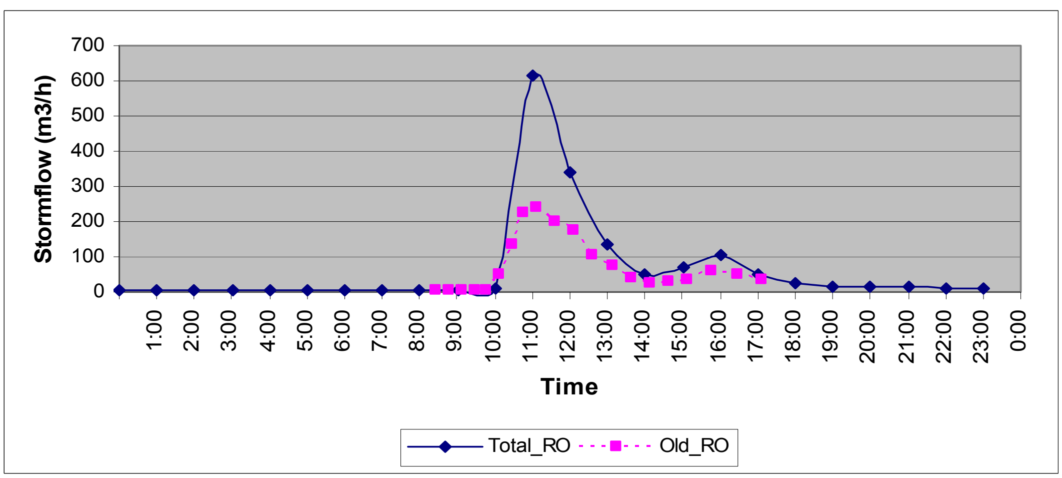

Figure 25. The 20 February 2003 even hydrograph separation. Dashed pink line indicates pre-event water contribution to the total storm runoff.

Some observation from vent hydrograph separation:

1. The total precipitation on 20 February 2003 was 48 mm over 24 hours.
2. The watershed response Q/P over 24 hours was about 8%.
3. Pre-event water contribution to the storm runoff ranged from 41 to 84 percent.

This analysis indicates the importance of subsurface flow in runoff generation in this watershed and the possible storage effects. However, conclusion from one hydrograph separation could be biased.