

Feather River Coordinated Resource Management Watershed Monitoring Program 2012 Report



February 26, 2012 at Notson Bridge.

Prepared by Plumas Corporation
Quincy, CA
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Abbreviations Used in this Report

Abv-	Above
Acw-	Above confluence with
Avg-	Average
Blw-	Below
CDEC-	California Data Exchange Center
CRS-	Continuous Recording Station
DWR-	California Department of Water Resources
EBNFFR-	East Branch North Fork Feather River
EPA-	US Environmental Protection Agency
FRCRM-	Feather River Coordinated Resource Management
Max-	Maximum

Min-	Minimum
MFFR-	Middle Fork Feather River
MR-	Monitoring Reach
NTU-	Nephelometric Turbidity Unit
RAC-	Resource Advisory Committee
SCI-	Stream Condition Inventory
SWAMP-	Surface Water Ambient Monitoring Program
Temp-	Temperature
TMDL-	Total Maximum Daily Load
USFS-	US Forest Service
USGS-	US Geological Survey
WY-	Water year

Introduction to Feather River Coordinated Resource Management Monitoring Program

2012 Monitoring Report Summary

This report tiers to Feather River Coordinated Resource Management (FRCRM) monitoring reports from 1999 through 2011. The 2012 Water Year (October 1, 2011- September 30, 2012) was a below average water year with 79% of normal historic precipitation for the entire Feather River Basin. The Quincy (US Forest Service gage) and Portola (CA Dept. Water Resources [DWR] gage) stations recorded percent of normal historic precipitation higher than the basin average. Quincy reported 83% of normal and Portola 79% of normal historic precipitation. There were two small storm events this water year. Both events were less than a two year event at the DWR gage on Indian Creek below Indian Falls. Summer average air temperature in the following chart is an average of DWR weather stations at Antelope Lake, Doyle Crossing, Quincy, and Grizzly Ridge from June 1 through September 30. The average summer air temperature for 2012 was 63.4°F, which is just slightly above the average temperature for all 13 years. The DWR weather station at Doyle Crossing was not recording for the 2012 summer season.

This report includes data from FRCRM continuous recording stations operated by Plumas Corporation, as well data from US Geological Survey (USGS), DWR, and US Forest Service (USFS) continuous recording stations.

Most important findings in this monitoring report:

- Downward trend in diurnal temperature fluctuation on Last Chance Creek at Doyle Crossing and Red Clover Creek at Notson Bridge (see Figure 6).
- A 0.5°F decrease in water temperature from pre- to post-restoration conditions on Red Clover Creek at Notson Bridge (see page19 and Figure 7).

Data Issues

- Flourney Bridge water temperature logger was not recording from Nov 18, 2011- Aug 3, 2012.
- Indian Creek at Taylorsville is not represented in most of the graphs, because the sensor was out of the water, only collecting high flow data. Funding has been provided by the USFS Resource Advisory Committee (RAC), Title II funds, to install a low flow sensor in 2013.
- Turbidity sensor on Indian Creek at Taylorsville failed in 2009. The sensor will be replaced with USFS RAC funds in 2013.
- Last Chance Creek at Million Dollar Bridge had a logger failure from Dec 7, 2011 through the end of the water year.
- DWR weather station at Doyle Crossing was not collecting precipitation, relative humidity, and temperature from May 11, 2012 through the end of the water year.

About the Feather River Coordinated Resource Management Group

The FRCRM, a consortium of 24 public agencies, private sector groups, and local landowners, was established in 1985 in response to widespread erosion and channel degradation in the Feather River watershed. One hundred and forty years of intensive human use has contributed to a watershed-wide stream channel entrenchment process. The FRCRM was able to initiate systematized monitoring in the Feather River watershed in 1999 to establish baseline data for assessing long-term trends in watershed condition and the potentially significant effects of restoration projects on watershed function. Most of the monitoring effort is concentrated in the Indian Creek subwatershed because of its highly degraded upper watershed condition, and high potential for benefit from restoration with many linear miles of alluvial channels. Monitoring site locations follow a nested approach. Please see the diagram at the end of the report that shows monitoring station locations with project locations.

Watershed Monitoring Program Background

Background information such as an overview of the watershed, monitoring program objectives, more detailed earlier data, and protocols can be found in the FRCRM watershed monitoring reports from 2003 and 2005. Reports can be found on the monitoring page of the FRCRM website at www.feather-river-crm.org. The monitoring network was installed in 1999 and data have been collected from 2000-2012.

Initial funding for the FRCRM's monitoring program was provided to Plumas Corporation through a Clean Water Act 319(h) grant (Aug 1998 to Dec 2000). Subsequent funding sources were: the California Surface Water Ambient Monitoring Program (SWAMP) from Oct 2000 to Dec 2003 and the Plumas Watershed Forum (2004 to 2006). Funding has been provided by the USFS RAC, Title II funds, to operate and maintain the continuous recording stations in 2012.

Monitoring Program Description

This report documents on-going monitoring data from the 2012 Water Year (WY) (October 1, 2011-September 30, 2012).

Three main subwatersheds of the Feather River are covered under this monitoring program:

- Indian Creek
 - Spanish Creek
 - Middle Fork Feather River
 - North Fork Feather River
- } **East Branch North Fork Feather River**

Data Collected at the Continuous Recording Stations:

- **Stage** (calibrated to flow)
- **Water Temperature**
- **Air Temperature** (except at Wolf Creek and DWR Weir)
- **Turbidity** (NTU's) - currently only at Indian Creek at Taylorsville (not functioning since 2009)

Stream flow stage, air and water temperature are recorded every 15 minutes by Campbell CR10X data loggers at the following FRCRM monitoring stations: Red Clover Creek at Notson Bridge; Last Chance Creek at Doyle Crossing and at Million Dollar Bridge; Cottonwood Creek above and below Big Flat (not on map); Indian Creek at the DWR weir (above the confluence of Red Clover Creek); Indian Creek at the Flournoy Bridge (below the confluence of Red Clover Creek); and Indian Creek at the Taylorsville Bridge; Lights Creek at Deadfall Lane Br.; and Wolf Creek at the Ball Field Bridge in Greenville; Spanish Creek at Dyrr Bank near Gansner Park in Quincy (2003-2010); and Sulphur Creek at Hwy 89 Br (2005-2006).

The stage, air and water temperature readings are stored as hourly averages and then summarized into daily files at the end of each water year. To continuously record turbidity, an Analite 195 laser sensor (a nephelometric probe) was installed on Indian Creek at Taylorsville Bridge in 2001 and on Spanish Creek (2001-06). The data loggers are capable of storing up to six months of data. Plumas Corporation staff and contract technicians download data monthly to ensure reliable station operation. Because of periodic channel shifts at most of the stations, monthly calibration measurements are required. Plumas Corporation staff is also responsible for capturing discharge measurements over the range of flows at each station in order to maintain/update the rating tables. Rating tables are reviewed and/or updated annually by Sagraves Environmental Services, Red Bluff.

Table 1. Watershed Area above Continuous Recording Stations

Watershed Area above Continuous Recording Stations (for station location see Figure 1)	
Station	Area (acres)
Last Chance at Doyle Crossing	61,746
Red Clover at Notson Bridge	69, 121
Indian Creek at DWR Weir	72,619
Indian Creek at Fournoy Bridge	281,132
Indian Creek at Taylorsville	343,193
Lights Creek at Deadfall Bridge	67,722
Wolf Creek at Ball Field Bridge	31,945

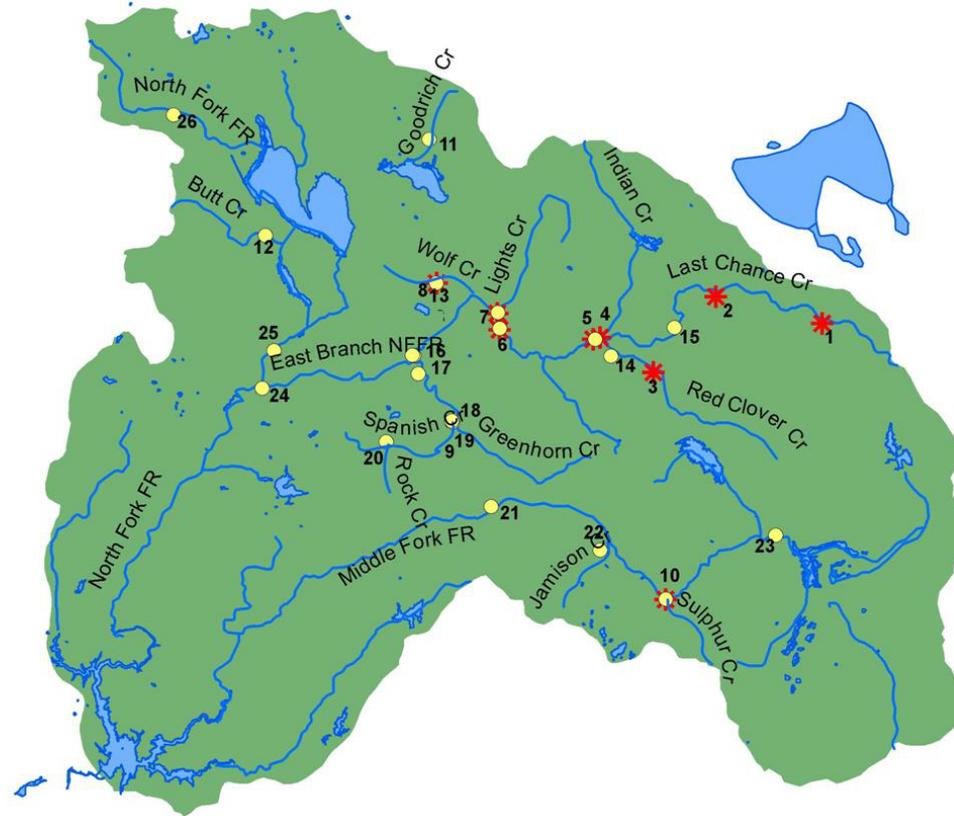
DWR Flow & Weather Stations

DWR maintains four weather stations and two continuous recording flow stations in the Feather River watershed to assist in managing the water resources. The DWR flow stations are located on Indian Creek below Indian Falls (ICR) and on the Middle Fork Feather River near Portola (MFP). Four weather stations installed by DWR in the Indian Creek watershed include Doyle Crossing (DOY) in 2000, Jordan Peak (JDP) in 2005, Thompson Valley (TVL) in 2006 and Taylorsville (TAY) in 2007. All of the DWR weather and flow stations are accessible on the DWR California Data Exchange Center (CDEC) website at cdec.water.ca.gov. Stream discharge and stage height are recorded at the DWR flow stations, while the DWR weather stations record precipitation, temperature, relative humidity, wind speed, wind direction, solar radiation and atmospheric pressure.

USFS Flow Stations

The USFS installed three continuous recording flow stations in the Feather River watershed in November and December 2011. These stations are located on Rowland Creek at the confluence with Little Last Chance Creek, Sulphur Creek below the confluence with McKenzie Creek, and Spanish Creek at the lower Spanish Ranch Bridge. Water pressure and temperature and atmospheric pressure and temperature are being continuously recorded using HOBO U20-001-04 loggers. These flow stations will be operated and calibrated by the USFS.

Figure 1. Feather River CRM Continuous Recording & Monitoring Reach Locations



* Continuous Recording Stations

• Monitoring Reaches

- | | |
|--|---|
| 1. Last Chance Creek @ Million Dollar Bridge | 15. Last Chance Creek Blw Murdock Crossing |
| 2. Last Chance Creek @ Doyle Crossing | 16. Indian Creek Abv Spanish Creek |
| 3. Red Clover Creek @ Notson Bridge | 17. Spanish Creek Abv Indian Creek |
| 4. Indian Creek @ DWR Weir | 18. Greenhorn Creek Mouth |
| 5. Indian Creek @ Flornoy Bridge | 19. Spanish Creek Abv Greenhorn Creek |
| 6. Indian Creek @ Taylorsville Bridge | 20. Rock Creek Mouth |
| 7. Lights Creek @ Deadfall Lane Bridge | 21. Middle Fork Feather River Abv Nelson Cr |
| 8. Wolf Creek @ Ball Field Bridge | 22. Jamison Creek |
| 9. Spanish Creek @ Dyrr Bank | 23. Middle Fork Feather River @ Beckwourth |
| 10. Sulphur Creek @ Hwy 89 Bridge | 24. East Branch North Fork Feather River Abv North Fork Feather River |
| 11. Goodrich Creek | 25. North Fork Feather River Abv East Branch North Fork Feather River |
| 12. Butt Creek | 26. North Fork Feather River Abv Lake Almanor |
| 13. Wolf Creek Abv Town Park | |
| 14. Red Clover Creek Blw Drum Bridge | |

Table 2. Upper Feather River Watershed Monitoring Sites-

<u>Map #</u>	<u>Monitoring Site by Subwatershed</u>	<u>Monitoring Type</u>	<u>Yrs Surveyed/ of Operation</u>
	North Fork Feather River (NFFR) watershed		
26	NFFR @ Domingo Springs (abv Lake Almanor)	MR*	99, 01, 03
	NFFR@ Seneca (blw Lake Almanor)	MR	99, 01, 03
25	NFFR @ above confluence with (acw) East Branch NFFR	MR	99, 01, 03
12	Butt Cr (abv 307 Br)	MR	99, 01, 03
11	Goodrich Cr	MR	99, 01, 11
24	East Branch mouth (acw NFFR)	MR	99, 01, 03, 11
17	Spanish mouth (acw Indian)	MR	99, 01, 03, 11
	Spanish Creek @ Keddie abv Blackhawk Cr.	CRS (USGS)	1933- present
19	Spanish Cr acw Greenhorn Cr	MR	99, 01, 03, 11
	Spanish Cr @ Spanish Ranch Br	CRS (USFS)	Dec 2011- present
18	Greenhorn Cr acw Spanish Cr	MR	99, 01, 03, 11
9	Spanish @ Quincy	CRS (USGS)	09- present
9	Spanish @ Dyrr Bank (Hwy 70)	CRS	2003-09
20	Rock Cr mouth	MR	99, 01, 03, 11
16	Indian Cr acw Spanish Cr (FRCRM) blw Indian Falls (DWR)	MR & CRS (DWR)	99, 01, 03, 11/ 07-present
13	Wolf Cr @ Ball Field Br	MR & CRS [†]	99, 01, 03, 11/ 09-present
7	Lights Cr @ Deadfall Lane Br	MR & CRS	99, 01, 03, 11/ 99-present
6	Indian Cr @ Taylorsville (TAY)	MR & CRS & Weather Station (DWR)	99, 01, 03, 11/ 99-present/ 07-present
5	Indian Cr @ Flournoy (below confluence with [bcw] Red Clover)	MR & CRS	99, 01, 03, 11/ 99-present
4	Indian Cr @ DWR weir (acw Red Clover)	CRS	99-present
	Red Clover Cr @ Chase Bridge	MR	99, 01, 03, 09
	Thompson Valley (TVL)	Weather Station (DWR)	06-present
14	Red Clover Cr @ Drum Bridge	MR	99, 01, 03
3	Red Clover @ Notson Bridge	CRS	99- present
15	Last Chance (LC) Cr @ Murdock	MR	99, 01, 03
2	Last Chance (LC) Cr @ Doyle Crossing (DOY)	CRS & Weather Station (DWR)	99- present/ 00-present
	McClellan Cr	MR (DWR)	97, 01, 05, 10

* Monitoring Reaches (MR) refers to those surveyed by FRCRM unless otherwise noted in parentheses.

† Continuous Recording Stations (CRS) are maintained and operated by FRCRM unless otherwise noted in parentheses.

Table 2 Cont.

<u>Map #</u>	<u>Monitoring Site by Subwatershed</u>	<u>Monitoring Type</u>	<u>Yrs Surveyed/ of Operation</u>
	Cottonwood Cr @ Big Flat	CRS abv & blw Big Flat	94-present
	Little Stoney Cr	MR (DWR)	97, 01, 05, 10
	Willow Cr	MR (DWR)	97, 01, 05, 10
	LC @ Alkali Flat low water crossing	MR (DWR)	97, 01, 05, 10
	Ferris Cr	MR (DWR)	97, 01, 05, 10
1	LC @ Million Dollar Bridge	CRS	04-present
	LC @ Bird-Jordan	MR (DWR)	97, 01, 05, 10
	Jordan Peak (JDP)	Weather Station (DWR)	05-present
	Middle Fork Feather River (MFFR) watershed		
21	MFFR abv Nelson Cr	MR	99, 01, 03, 11
	MFFR @ Sloat	staff gage	2003- present
22	Jamison Cr @ 23N37 Br	MR	99, 01, 03, 11
	Rowland Cr at cw Little Last Chance	CRS (USFS)	Dec 2011-present
10	Sulphur Cr @ Hwy 89 (Clio)	MR	99, 01, 03, 11
	Boulder Cr	staff gage	2003- 08
	Barry Cr	staff gage	2003- present
	Sulphur @ Lower Loop Bridge	staff gage	2003- present
	Sulphur below confluence with McKinzie Cr	CRS (USFS)	Dec 2011-present
	Sulphur @ Upper Loop Bridge	staff gage	2003- present
23	MFFR blw A23 Br (Beckwourth)	MR	99, 01, 03, 11
	MFFR near Portola (MFP)	CRS (DWR)	06- present

2012 Monitoring Program Findings

Table 3. Precipitation and Summer Air Temperature Averages

Water Year (10/1-9/30)	Percent of Historic Average annual precip for the entire Feather River Basin from CDEC*	Total annual precip (inches) at Indian Cr in Genesee (Wilcox data)**	Summer Average Air Temperature ⁺
1996		59.25	
1997		61.6	
1998	144%	60.9	
1999	99%	47.2	
2000	101%	43.3	61.4
2001	56%	21.2	63.0
2002	77%	33.3	62.3
2003	111%	50.7	63.2
2004	83%	41.15	61.7
2005	109%	45.5	60.5
2006	154%	66.25	62.3
2007	60%	31.05	61.5
2008	68%	25.4	62.9
2009	84%	38.05	62.6
2010	101%	33.85	61.4
2011	142%	56.60	64.9
2012	79%	33.85	63.4
Average		44.1	62.4

* Averages derived by DWR from all reporting stations in the watershed. The ten stations in the Feather River Watershed are Plumas Eureka Park, Sierraville, Vinton, Portola, Chester, Strawberry Valley, Brush Creek, Greenville, Quincy, and Nicolaus. In 2012 7/10 stations were reporting averages (Sierraville, Vinton, Portola, Chester, Strawberry Valley, Brush Creek, Quincy).

** The values in the Indian Creek in Genesee Precip column are unrelated to the Percent of Historic Average Annual Precip values. The Percent Historic Average is an average of weather stations throughout the watershed, which is calculated by DWR.

⁺ Average derived from DWR weather stations at Antelope Lake, Doyle Crossing, Grizzly Ridge, and Quincy. Data is missing from Doyle Crossing in 2000 and 2012, Grizzly Ridge in 2001, and Antelope Lake in 2007.

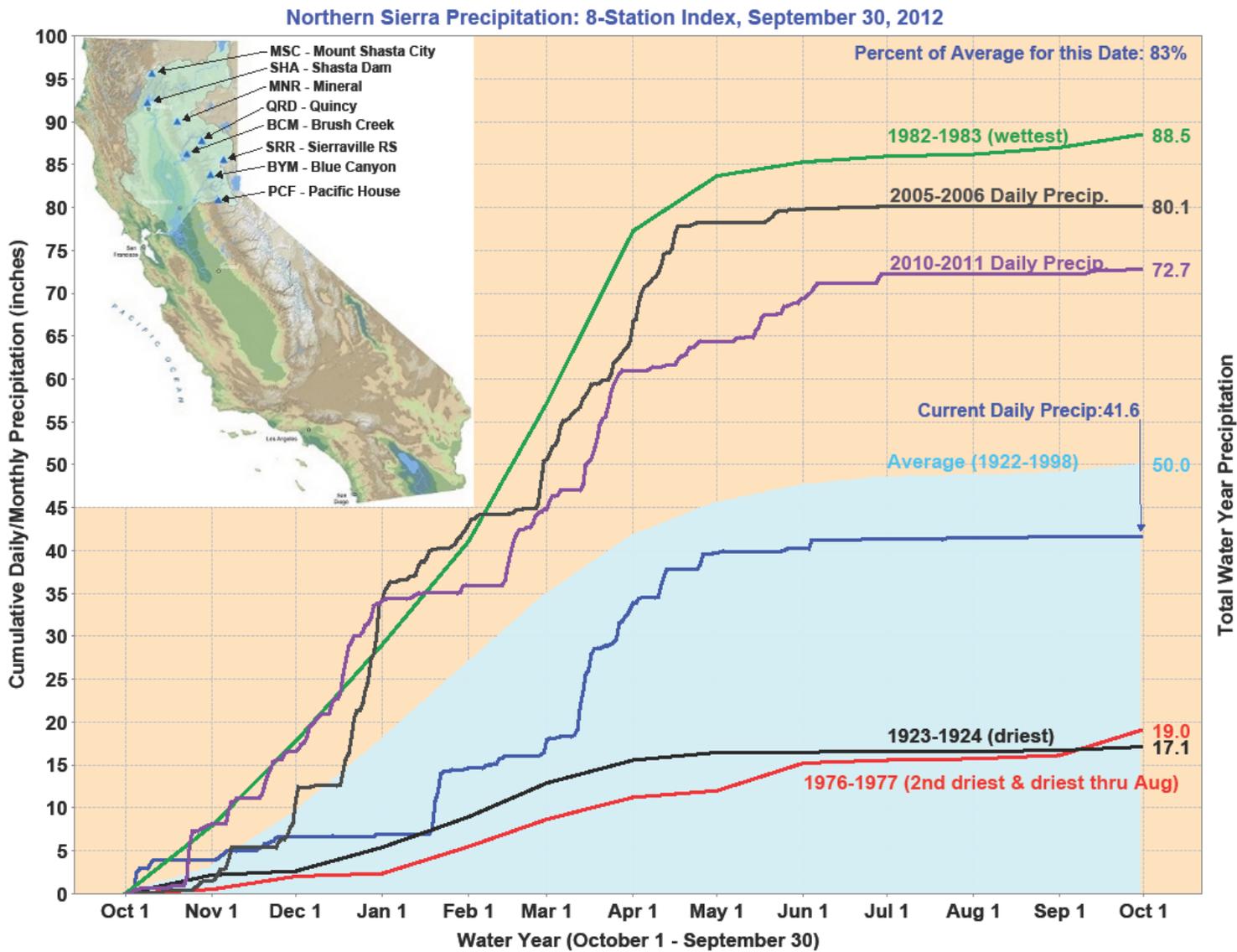


Figure 2. DWR Historic Precipitation for the Northern Sierra. 2012WY in dark blue.

Water Temperature

Introduction

The Central Valley Regional Water Quality Control Board has identified water temperature as a water quality concern in the Feather River watershed. A variety of parameters were used to compare water temperature between sites and between years. Figures 3-6 analyze water temperatures from six continuous recording stations in the Indian Creek watershed with usable data for the 2012WY. In previous reports it has been a challenge to fit all six stations on one chart and display all thirteen years of data in an understandable way. The 2010 and 2011 reports only displayed the long term data set for stations affecting Genesee Valley, which led to an incorrect conclusion regarding potential effects of restoration or other watershed activities on water temperature. This section includes all useable stations in the Indian Creek watershed. When looking at Figures 3-6 keep in mind that the Indian Creek at the DWR weir station is below Antelope Dam. Releases from Antelope Dam come from the bottom of the reservoir, which effects water temperature year round.

Seven Day Average of Daily Maximum Water Temperature

Figures 3 and 4 show seven day average of daily maximum water temperatures, which is calculated by taking a running seven day average of daily maximum water temperature for the entire water year. In Figure 4, the maximum value of the seven day averages is taken. Figure 3 shows the seven day average of daily maximum water temperatures for the entire 2012WY summer season. In past reports this section displayed the seven day average of daily mean temperatures. The US EPA found this metric masked regularly occurring large diurnal temperature variations out of a healthy range. The US EPA also found the seven day average of daily maximum temperatures is the metric identified as the most useful in providing full protection for the individual life-history stages of key species[‡].

Figure 3 displays the duration of temperatures above 66°F for each station and Figure 4 displays the water temperature data with summer average air temperature. Figures 3 and 4 show that Lights and Last Chance creeks are the two warmest channels in 2012. Figure 4 does not show much correlation between water temperature and summer average air temperature at all stations. It appears that Last Chance Creek at Doyle Crossing and Red Clover Creek at Notson Bridge have reduced seven day average maximum daily water temperatures after the implementation of meadow restoration projects in 2006 and 2007, respectively. It also appears that the Indian Creek at Flournoy Bridge and Lights Creek stations also loosely follow this pattern of reduced water temperatures after 2005. This reduction of seven day average daily maximum water temperatures may not be attributable to meadow restoration projects. Below are the trendline equations for each data set in Figure 4 with R² values. R² is a value between zero and one and describes how well a trend line fits the data points. A value near one indicates the trend line fits the data well. A value near zero indicates that the trend line does not fit the data well.

Last Chance at Doyle:	$y = -2.94x + 96.5$ R ² = 0.23	Indian blw Red Clover- Flournoy:	$y = -3.98x + 86.4$ R ² = 0.26
Red Clover at Notson:	$y = -0.85x + 80.3$ R ² = 0.73	Lights Creek:	$y = -0.71x + 69.0$ R ² = 0.01
Indian abv Red Clover- DWR Weir:	$y = -0.24x + 68.4$ R ² = 0.16	Wolf Creek:	$y = -0.36x + 55.1$ R ² = 0.0

[‡] US Environmental Protection Agency, 2001. Technical synthesis: Scientific issues relating to temperature criteria for salmon, trout, and char. EPA 910-R-01-007

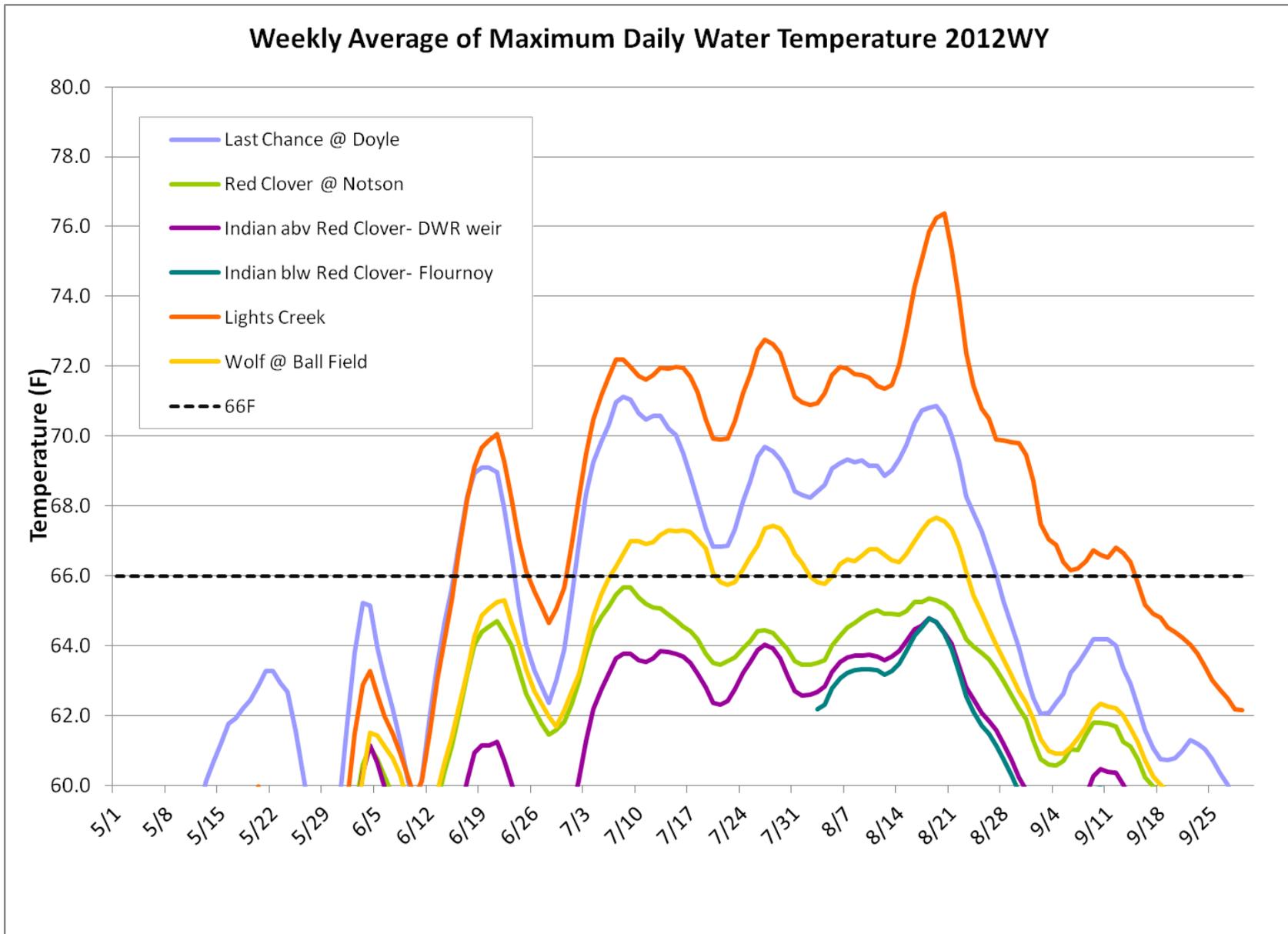


Figure 3. 2012 Seven Day Average of Daily Maximum Water Temperatures at all stations for summer season

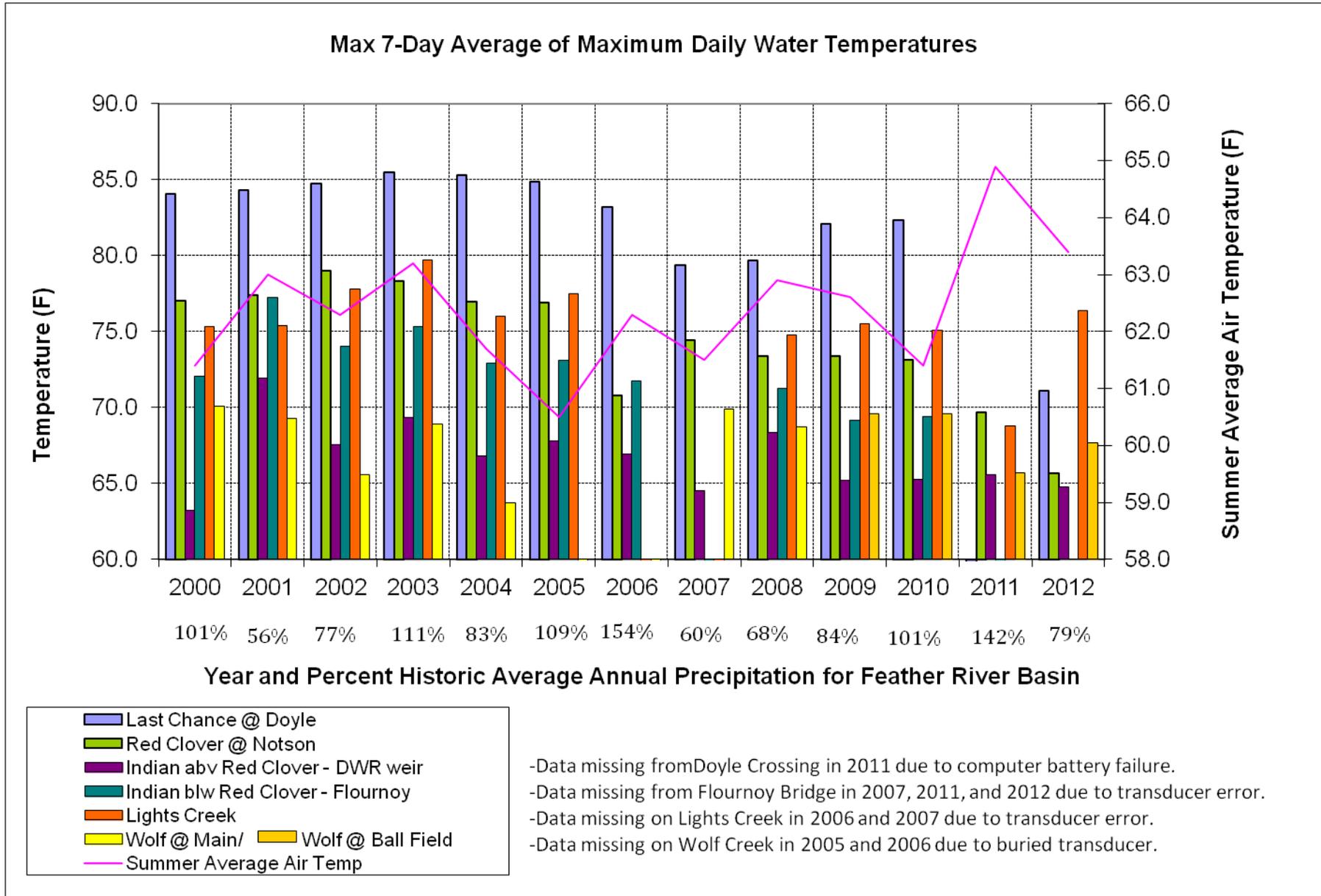


Figure 4. Maximum Seven Day Average of Maximum Daily Water Temperatures in 2000-2012 for all stations

Daily Maximum Water Temperature >70°F

In the past this metric looked at the number of days with an absolute one-hour temperature greater than 75°F. Over the years most stations no longer have many days over 75°F. Figure 5 displays the number of days with an absolute one-hour temperature greater than 70°F among the six continuous recording stations with usable low flow data from 2000-2012. 70°F is the total maximum daily load (TMDL) criteria set for temperature by the State of California for the North Fork Feather River 303(d) listing. 70°F (21°C) is the temperature that benefits a native cold water fishery.

Figure 5 shows that Last Chance and Lights creeks have the most impaired temperatures monitored over the past thirteen years. A downward trend in days above 70°F has been seen on Red Clover, Last Chance, Indian, and Lights creeks. Trendline equations show that Indian Creek at Fournoy Bridge, Last Chance and Red Clover creeks have a slightly steeper downward slope than Lights Creek. Trendline equations for each data set with R² values are below.

Last Chance at Doyle:	$y = -5.61x + 134.7$	$R^2 = 0.46$
Red Clover at Notson:	$y = -5.15x + 92$	$R^2 = 0.43$
Indian abv Red Clover- DWR Weir:	$y = -0.61x + 6.0$	$R^2 = 0.17$
Indian blw Red Clover- Fournoy:	$y = -5.33x + 60.7$	$R^2 = 0.55$
Lights Creek:	$y = -4.06x + 113.23$	$R^2 = 0.13$
Wolf Creek:	$y = -0.82x + 45.8$	$R^2 = 0.01$

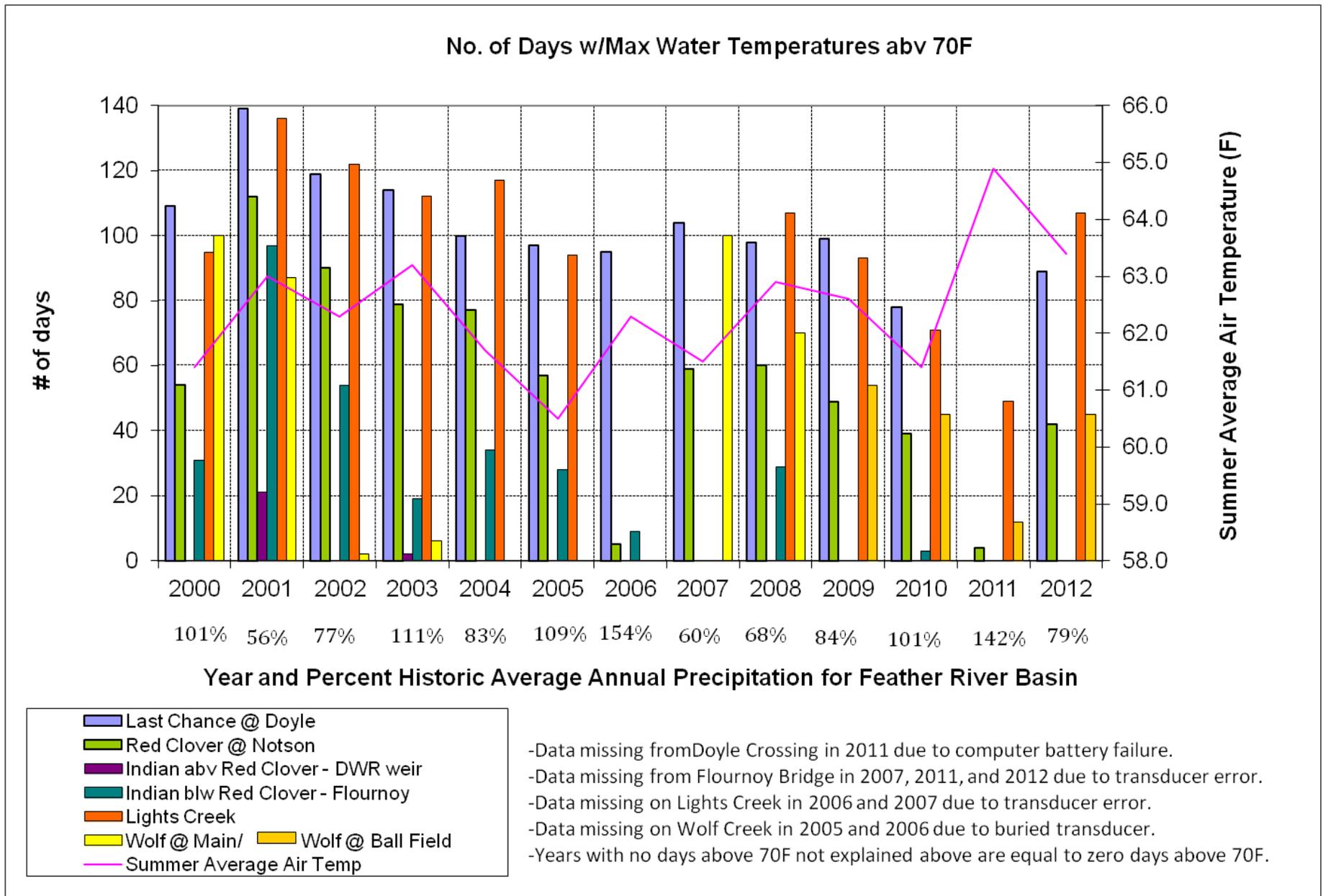


Figure 5. Number of days with maximum water temperature above 70F recorded in 2000-2012 for all stations

Maximum summer diurnal water temperature fluctuation

Figure 6 displays the maximum diurnal water temperature fluctuation. This is calculated by finding the difference between the maximum and the minimum water temperature in a 24-hour period (diurnal fluctuation). Then, a running seven day average of the diurnal fluctuation is calculated for June 1- Sept 30. Afterward the maximum value of the averages is taken. This parameter is heavily dependent on air temperatures and insolation. Figure 6 shows some of the smallest diurnal fluctuation in 2012 for the entire 2000-2012 period. Last Chance Creek and Red Clover Creek seem to have been experiencing smaller diurnal fluctuations since 2005 and 2006, respectively. These two data sets, along with Indian Creek at Flournoy Bridge, have the steepest downward trend of all six stations. This downward trend could be attributable to meadow restoration projects implemented in the Last Chance and Red Clover watersheds.

Last Chance at Doyle:	$y=-1.08x+27.3$	$R^2= 0.37$
Red Clover at Notson:	$y=-0.75x+20.7$	$R^2= 0.55$
Indian abv Red Clover- DWR Weir:	$y=-0.21x+9.3$	$R^2= 0.19$
Indian blw Red Clover- Flournoy:	$y=-1.09x+16.6$	$R^2= 0.59$
Lights Creek:	$y=-0.48x+17.0$	$R^2= 0.08$
Wolf Creek:	$y=-0.15x+11.2$	$R^2= 0.01$

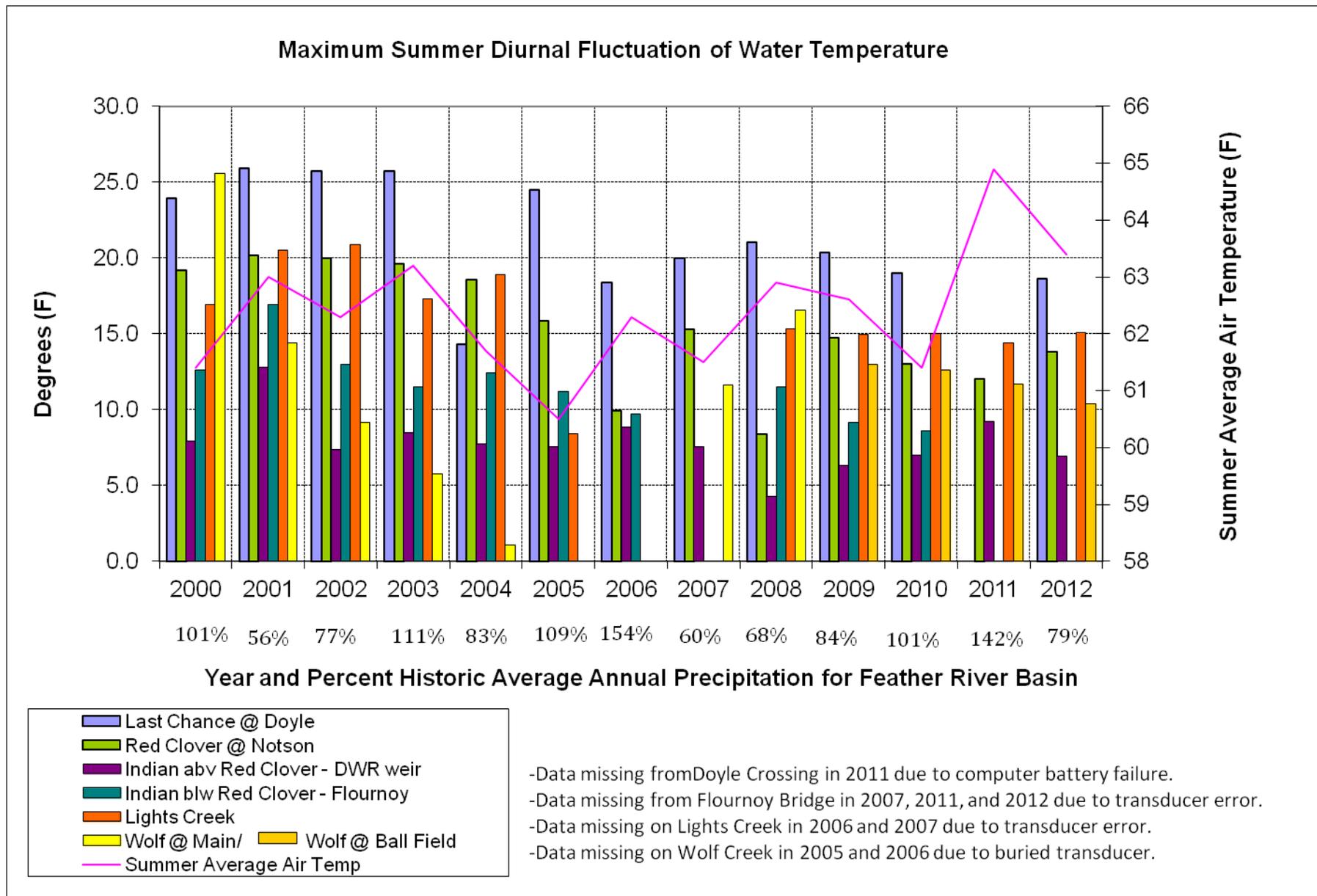


Figure 6. Maximum Diurnal Fluctuation of water temperature recorded in 2000-2012 for all stations.

Project specific water temp data

The relation of air temperature to water temperature was analyzed using analysis of covariance (ANCOVA) at Red Clover Creek at Notson Bridge and Last Chance Creek at Doyle Crossing. Figures 7 and 8 display the relationship between air and water temperature with regression lines and equations at Notson Bridge and Doyle Crossing, respectively. At Notson Bridge water years 2000-2005 represent pre-project conditions, and water years 2007-2012 represent post-project conditions. At Doyle Crossing water years 2000-2001 represent pre-project conditions, and water years 2008-2011 represent post-project conditions. After running ANCOVA at the two sites we found that there was a significant difference ($p < 0.0001$) in the slope of the regression lines at Doyle Crossing, which makes the ANCOVA analysis invalid. The significant difference indicates there is something affecting the relationship between air and water temperature at this site. Further data collection before and after the Last Chance Phase II project may help to clarify this relationship. At Notson Bridge there was no significant difference in the slope of the regression lines ($p = 5.4$) so the ANCOVA analysis at Notson Bridge was valid. ANCOVA showed a significant ($p < 0.0001$), negative shift in the y-intercept of the post-project regression line. This indicates that there is a significant decrease in water temperature at the same air temperature after the Red Clover Valley meadow restoration projects. This decrease is approximately 0.5°F from pre-project conditions at any given air temperature. It is postulated that this decrease in water temperature could be from increased groundwater influence on water temperature due to project construction, or due to increase shading in the channel from vegetation growth from the 1997 flood to 2012. During 2011 surveys of stream condition inventory sites, increased shading was observed in stream channels throughout the watershed, as compared to 1999, 2001, and 2003 surveys.

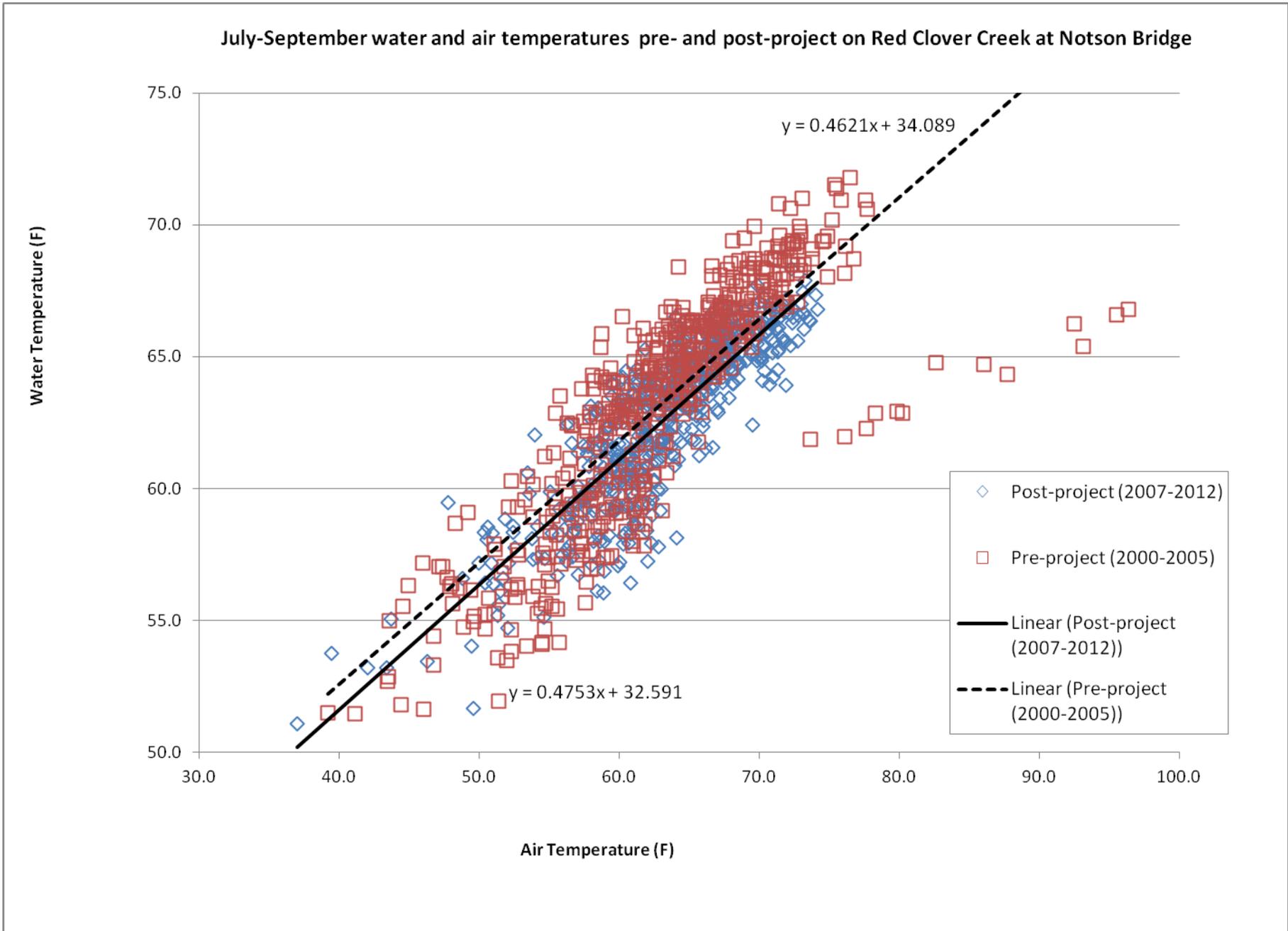


Figure 7. Summer air and water temperature pre- and post-project on Red Clover Creek at Notson Bridge.

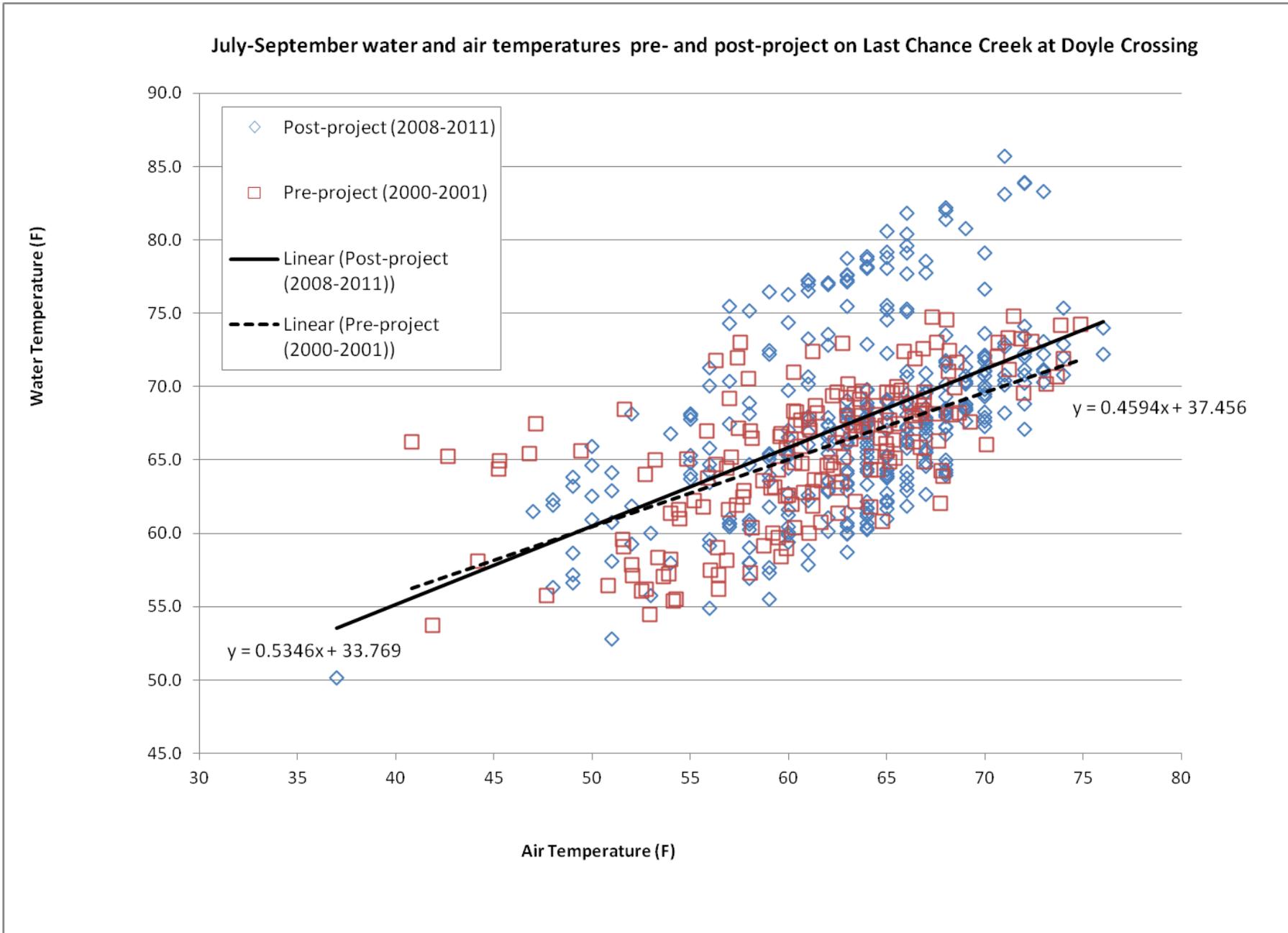


Figure 8. Summer air and water temperature pre- and post-project on Last Chance Creek at Doyle Crossing.

Discussion

Last Chance Creek at Doyle Crossing and Lights Creek are consistently the most temperature impaired channels, followed by Wolf Creek. This temperature impairment of Last Chance, Wolf, and Lights creeks may be from the diminishment of groundwater recharge and release function of the watershed above these stations. Maximum daily water temperature at Doyle Crossing continues to decline, but the locally high temperature readings at Doyle Crossing on Last Chance Creek is thought to be attributed to enhanced solar radiation from water sheeting over bedrock and a 400-foot long unshaded pool above the recording station. During May-October 2011 a HOBO temperature logger was placed upstream of this pool to record water temperature previous to flowing through the unshaded section of Last Chance Creek. The temperature recorded by the HOBO logger was on average 1.3 degrees Fahrenheit cooler than the temperature recorded by the continuous recording station.

Stream Flows

A primary purpose of the FRCRM's nested network of streamflow stations is to detect hydrologic change at increasing watershed scales. Data have been collected at these stations since 2000. Stations are located from ten to thirty miles downstream of the FRCRM's on-going project focus areas. The expectation is that potential surface and sub-surface base flow changes resulting from restoration would be detected down-watershed. The Indian Creek at DWR weir station is located below Antelope Dam. Releases from Antelope dam are regulated, which affects stream flow year round.

Figure 9 displays the average summer (July 1- Sept 30) stream flows from six continuous recording stations in the Indian Creek watershed with usable low flow data for the 2012WY. Precipitation in 2002 is relatively comparable to 2012. Figure 9 shows that average summer stream flows in 2002 were slightly greater than in 2012, except for Last Chance and Wolf creeks where flows were slightly higher in 2012 than 2002. Most August and September stream flows are trending minimally upward from 2000-2012, but in Ken Cawley's Statistical Analysis of Feather River CRM Stream Flow Data (2011) Ken found no apparent correlation (positive or negative) between stream restoration and base flow at either Notson Bridge or Doyle Crossing. This analysis was only conducted on stream flow from 2000-2010. The report is available on the FRCRM website. See trendline equations below.

Last Chance at Doyle:	$y=0.03x+0.5$	$R^2= 0.07$
Red Clover at Notson:	$y=0.01x+3.7$	$R^2= 0.0$
Indian abv Red Clover- DWR Weir:	$y=1.29x+10.7$	$R^2= 0.47$
Indian blw Red Clover- Flournoy:	$y=-0.13x+25.5$	$R^2= 0.01$
Lights Creek:	$y=0.87x-0.94$	$R^2= 0.19$
Wolf Creek:	$y=0.25x+2.1$	$R^2= 0.09$

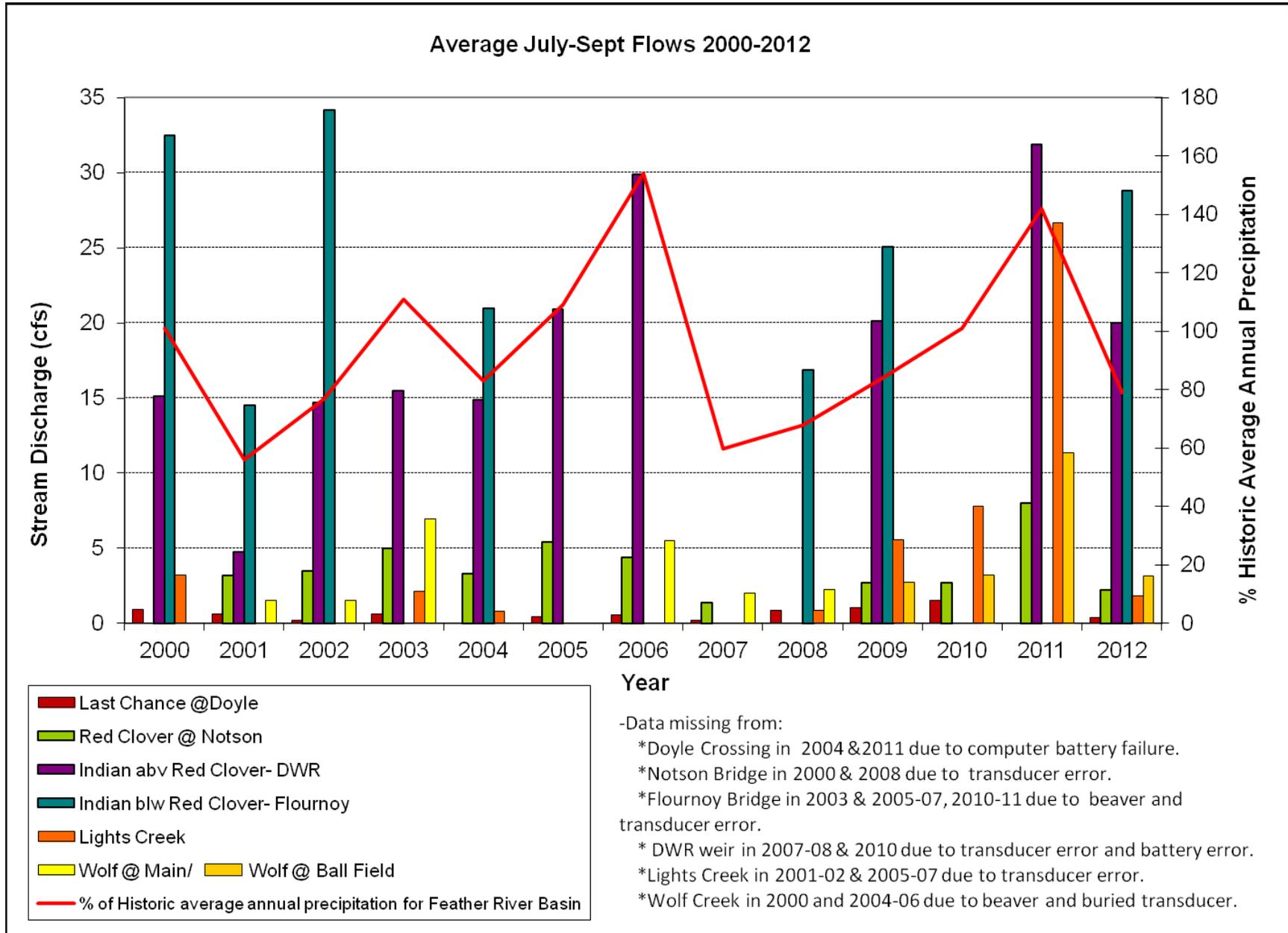


Figure 9. Average Summer Stream Flow from 2000-2012 on Last Chance Creek, Red Clover Creek, and Indian Creek above and below the confluence of Red Clover Creek

Station Specific Flow Data

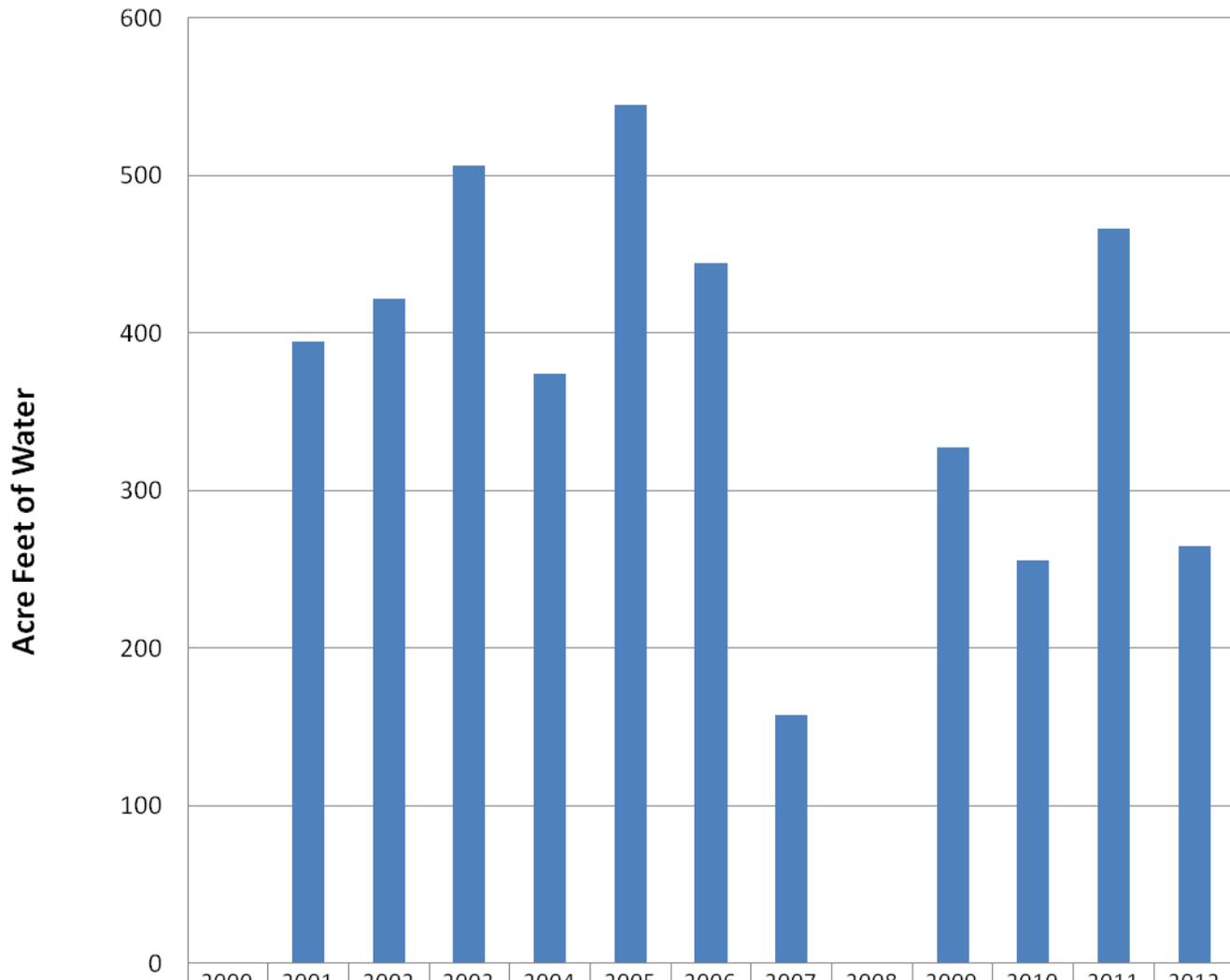
Figures 10 and 12 display the acre feet of water for Red Clover Creek at Notson Bridge and Last Chance Creek at Doyle Crossing, respectively, from August 1 through September 30 2000-2012. This is calculated by taking a sum of the stream flows in August and September for both stations. The following discussion compares 2002WY to 2012WY. The 2002 and 2012 water year had relatively similar percent historic precipitation, 77% and 79% respectively. Both continuous recording stations are located downstream of restoration project work. On Red Clover Creek, the Red Clover McReynolds project was constructed in 2006 and the Red Clover Poco project was constructed in 2010. Together these projects restored 538 acres of meadow floodplain. In the Last Chance creek watershed over 1,800 acres of meadow restoration occurred from 2001-2007.

Figure 10 displays Red Clover Creek at Notson Bridge. In August 1 through September 30, 2002 421.9 acre-feet of water passed by the gage. For the same dates in 2012, 265.1 acre-feet of water passed by the gage. There was a decrease of 156.8 acre-feet in August and September 2012 compared with 2002, an average of 2.57 acre-feet per day (1.3 cubic feet per second).

Figure 12 shows Last Chance Creek at Doyle Crossing. August 1 through September 30, 2002 there was 13.2 acre-feet of water. The same dates in 2012 show 37.6 acre-feet of water. There was an increase of 24.4 acre-feet in August and September 2012 compared with 2002, an average of 0.4 acre-feet per day (0.2 cubic feet per second). WY2000 and 2010 were also compared for the same time period in August and September. August 1 through September 30, 2000 there was 89.4 acre-feet of water. The same dates in 2010 show 130.6 acre-feet of water. There was an increase of 41.2 acre-feet in August and September 2010 compared with 2000, an average of 0.68 acre-feet per day (0.34 cubic feet per second).

Figures 11 and 13 show length of channel restored over time on Red Clover Creek and Last Chance Creek respectively. These charts are included to see if there is any trend or pattern related to stream restoration miles. Ken Cawley's Statistical Analysis of Feather River CRM Stream Flow Data report (2011) found no apparent correlation (positive or negative) between stream restoration and base flow at either Notson Bridge or Doyle Crossing. The statistical analysis only analyzed data collected through the 2010 water year. In 2013 the statistical analysis will be extended to cover the 2011 and 2012 water years.

Red Clover Creek at Notson Bridge Acre Feet of water for Aug and Sept



■ Acre Feet	0	394.5	421.9	506.4	374.1	544.5	444.4	157.8	0.0	327.3	255.9	466.1	265.1
Precip in Genesee for Aug-Sept (in)	0.75	0.45	0	0.80	0.05	1.25	0	1.10	0	0.15	0.20	0.40	0
Historic Average Annual Precip	101%	56%	77%	111%	83%	109%	154%	60%	68%	84%	101%	142%	79%

Figure 10: Acre feet of water in August and September at Notson Bridge 2000-2012

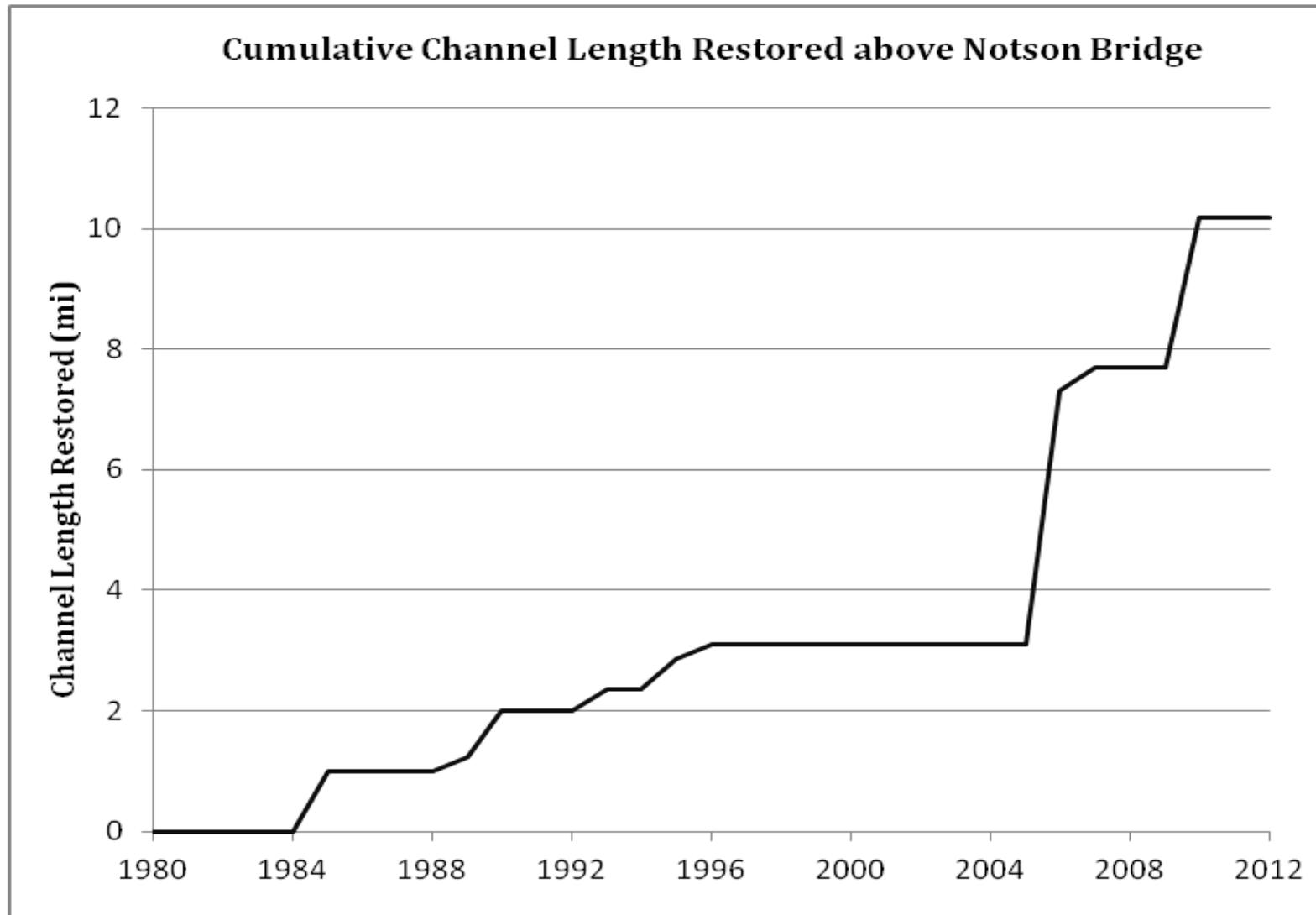
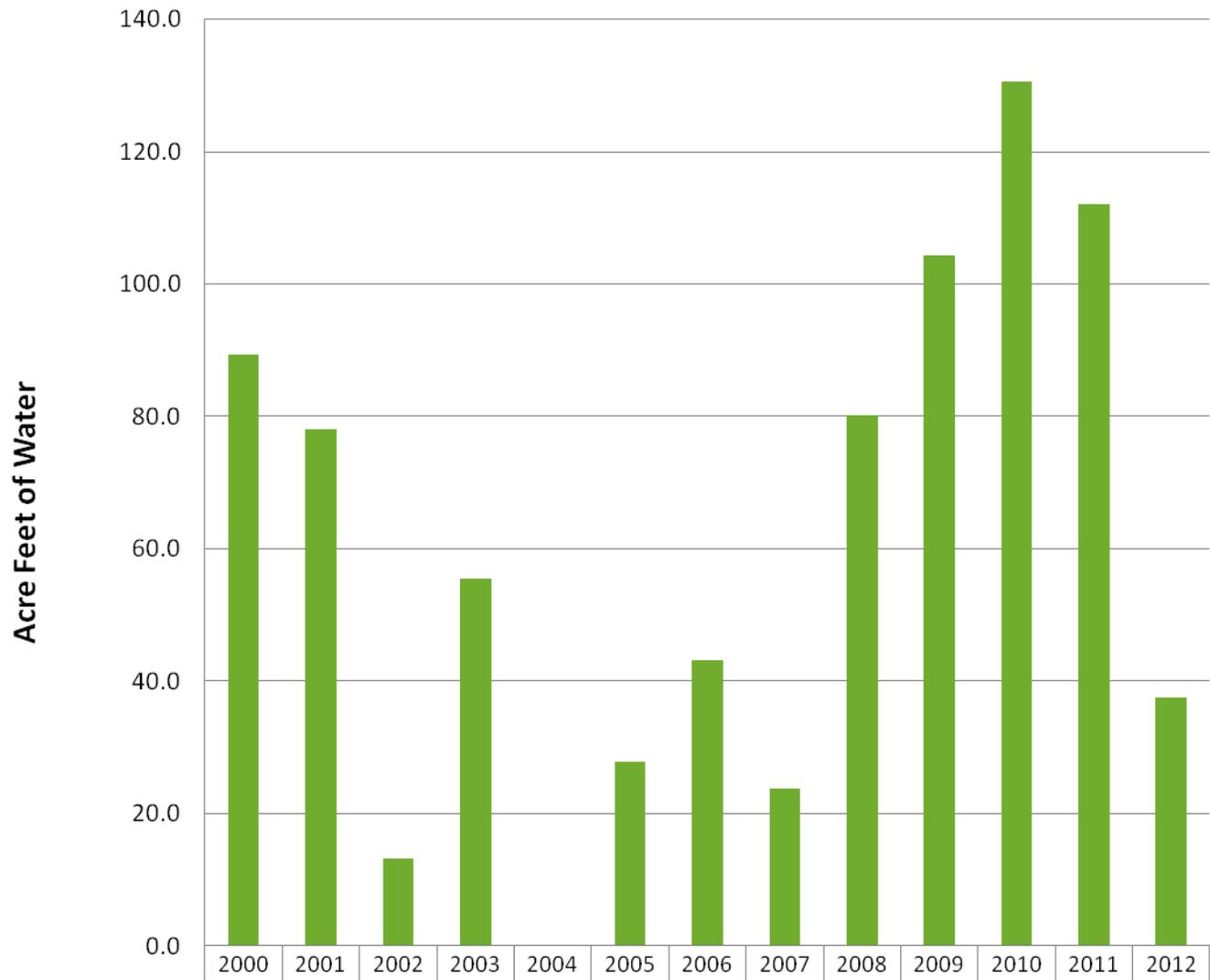


Figure 11: Length of restored channel over time on Red Clover Creek above Notson Bridge

Last Chance Creek at Doyle Crossing Acre Feet of water for Aug and Sept



■ Acre Feet	89.4	78.1	13.2	55.4	0.0	27.8	43.2	23.8	80.1	104.4	130.6	112.1	37.6
Precip at Doyle Xing for Aug-Sept (in)	0.37	0.76	0.93	1.67	0.13	0.88	0.23	0.57	0.03	0.19	0.32	0.06	1.60
Historic Average Annual Precip	101%	56%	77%	111%	83%	109%	154%	60%	68%	84%	101%	142%	79%

Figure 12: Acre feet of water in August and September at Doyle Crossing 2000-2012

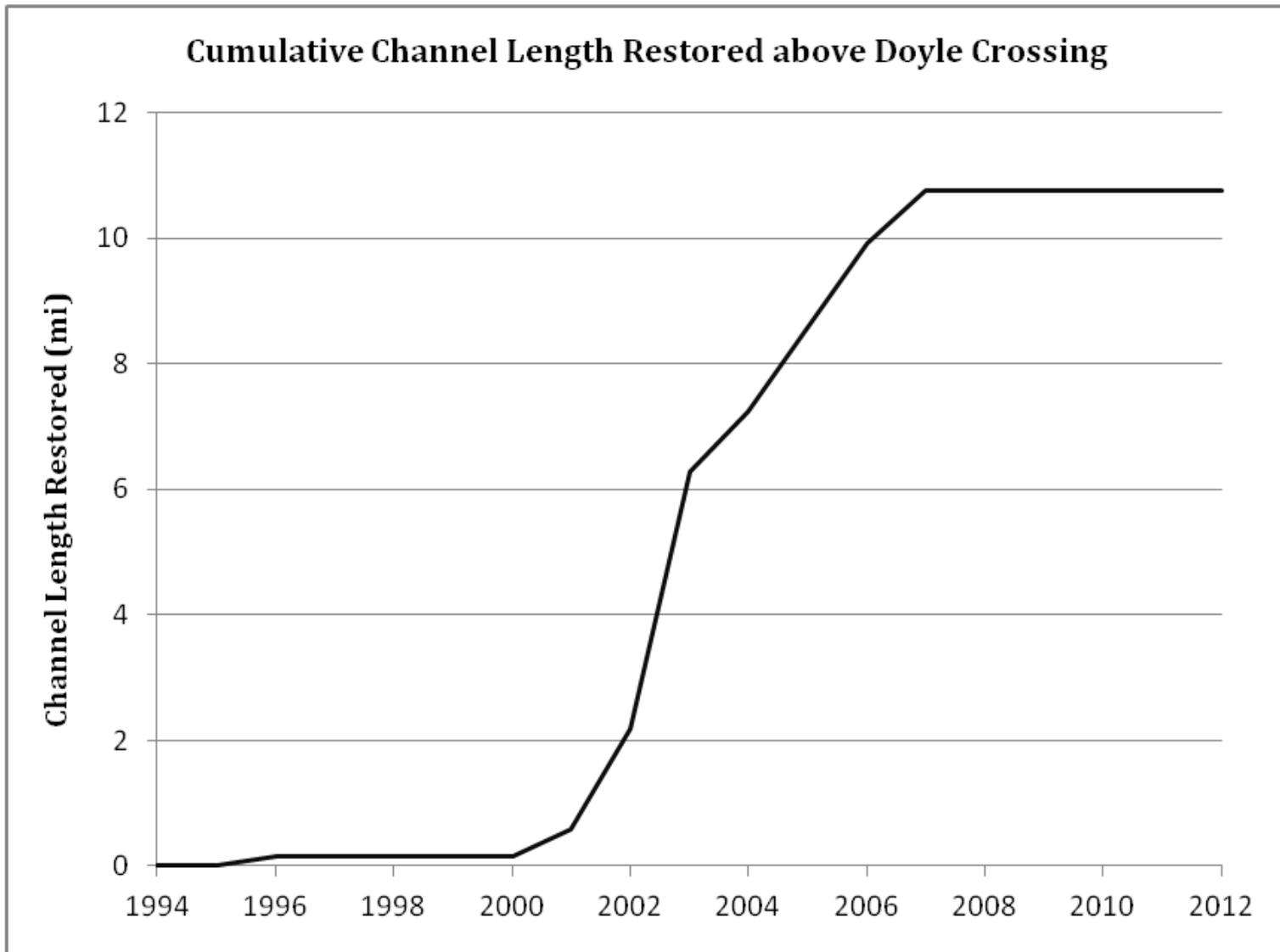


Figure 13: Length of restored channel over time on Last Chance Creek above Doyle Crossing

Watershed Hydrographs- Daily Average Stream Flow from continuous recording stations WY2012 (precipitation data taken at nearby weather stations)

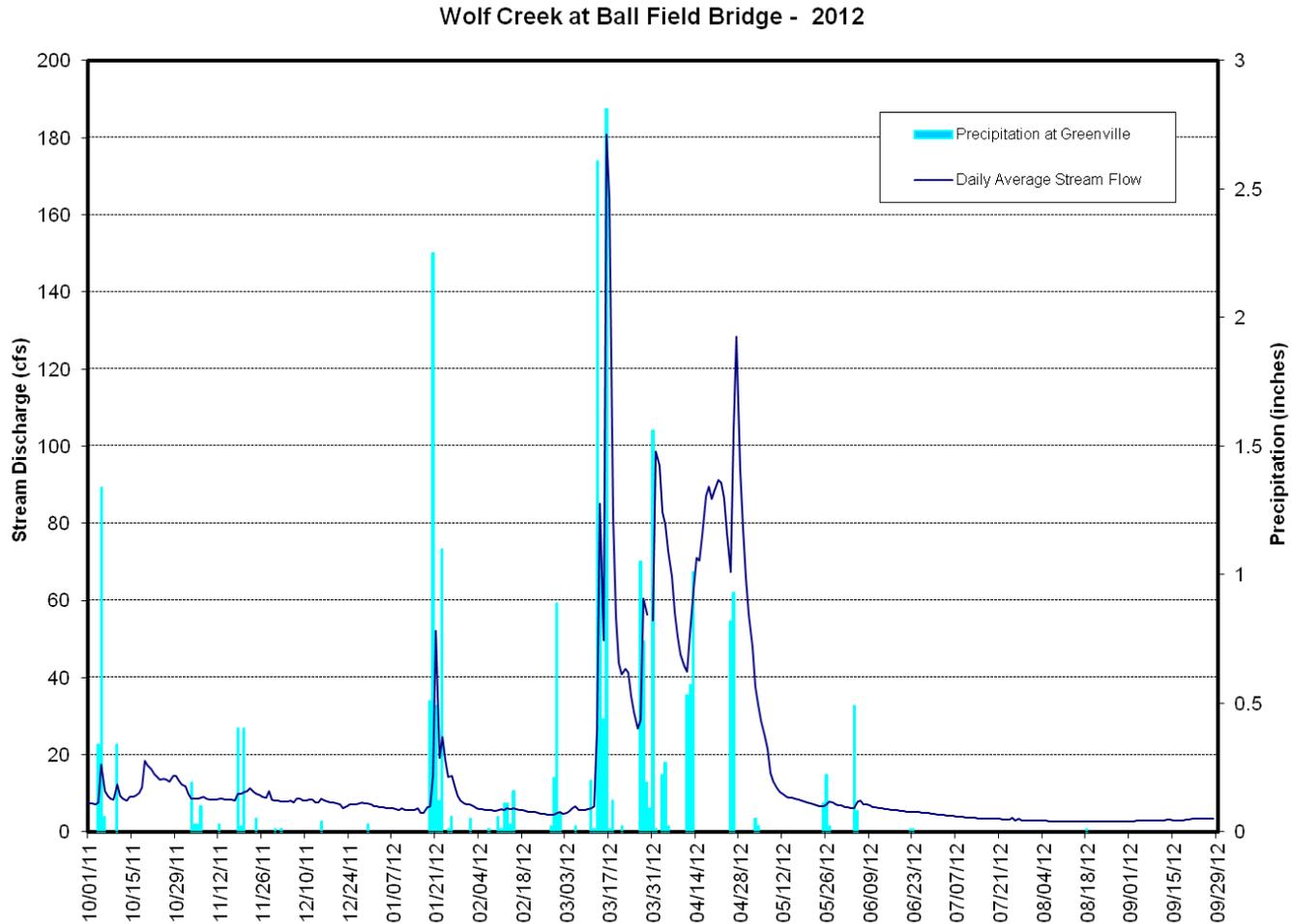


Figure 14: Wolf Creek at Ball Field Bridge Hydrograph 2012WY

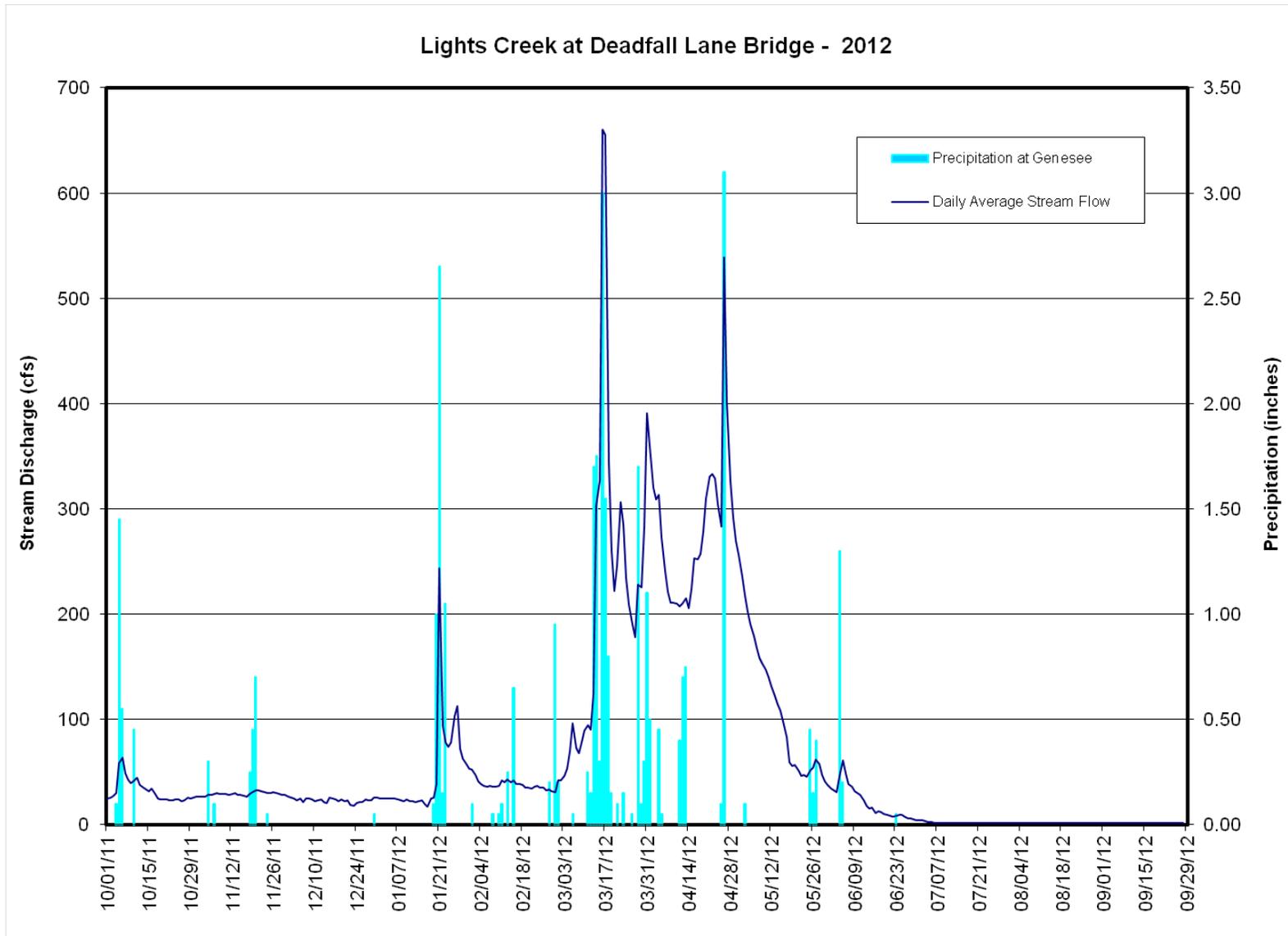


Figure 15: Lights Creek at Deadfall Lane Bridge Hydrograph 2012WY

Indian Creek at DWR Weir - 2012

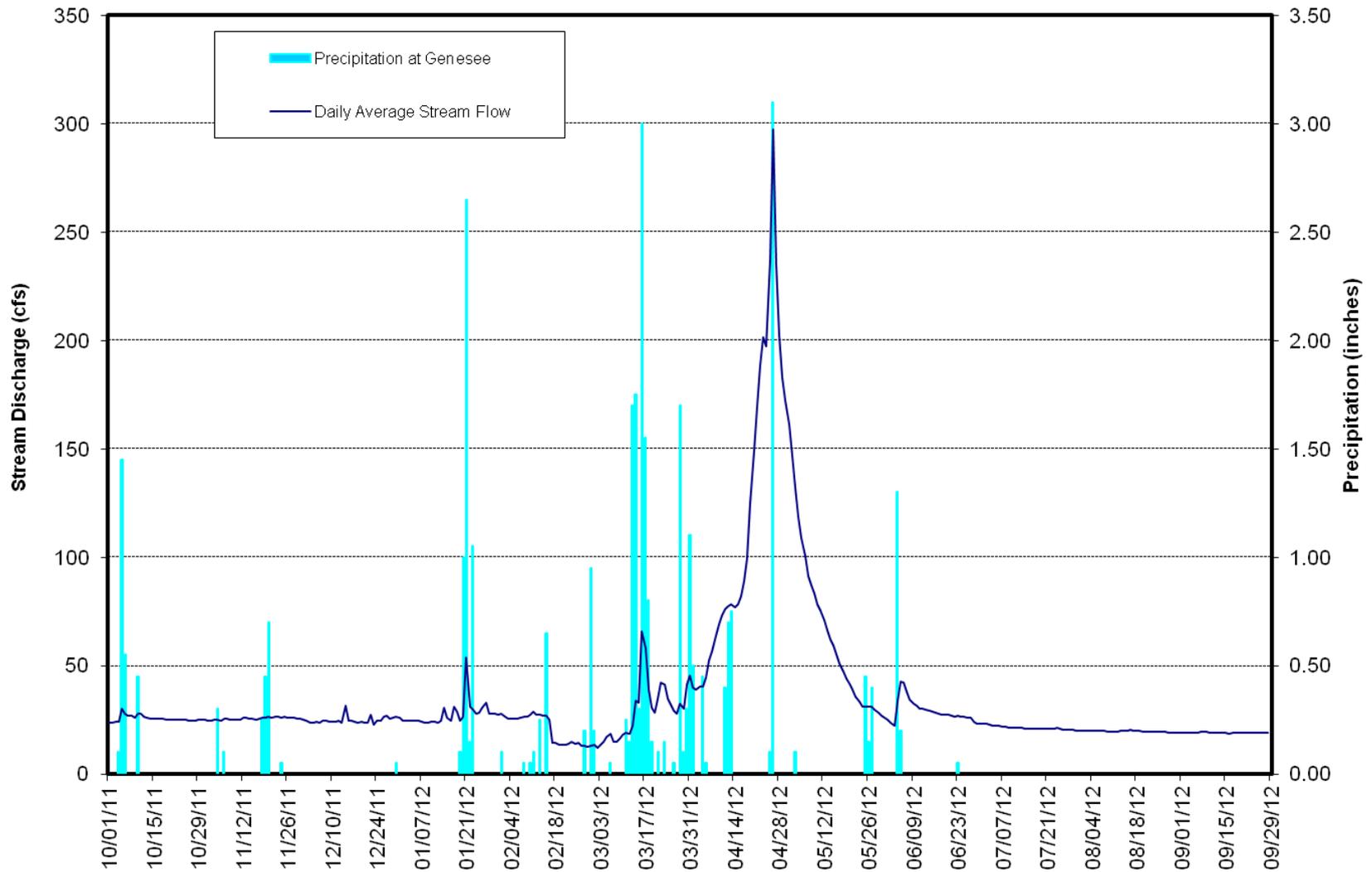


Figure 16: Indian Creek at DWR Weir Hydrograph 2012WY

Indian Creek at Flourney below Red Clover - 2012

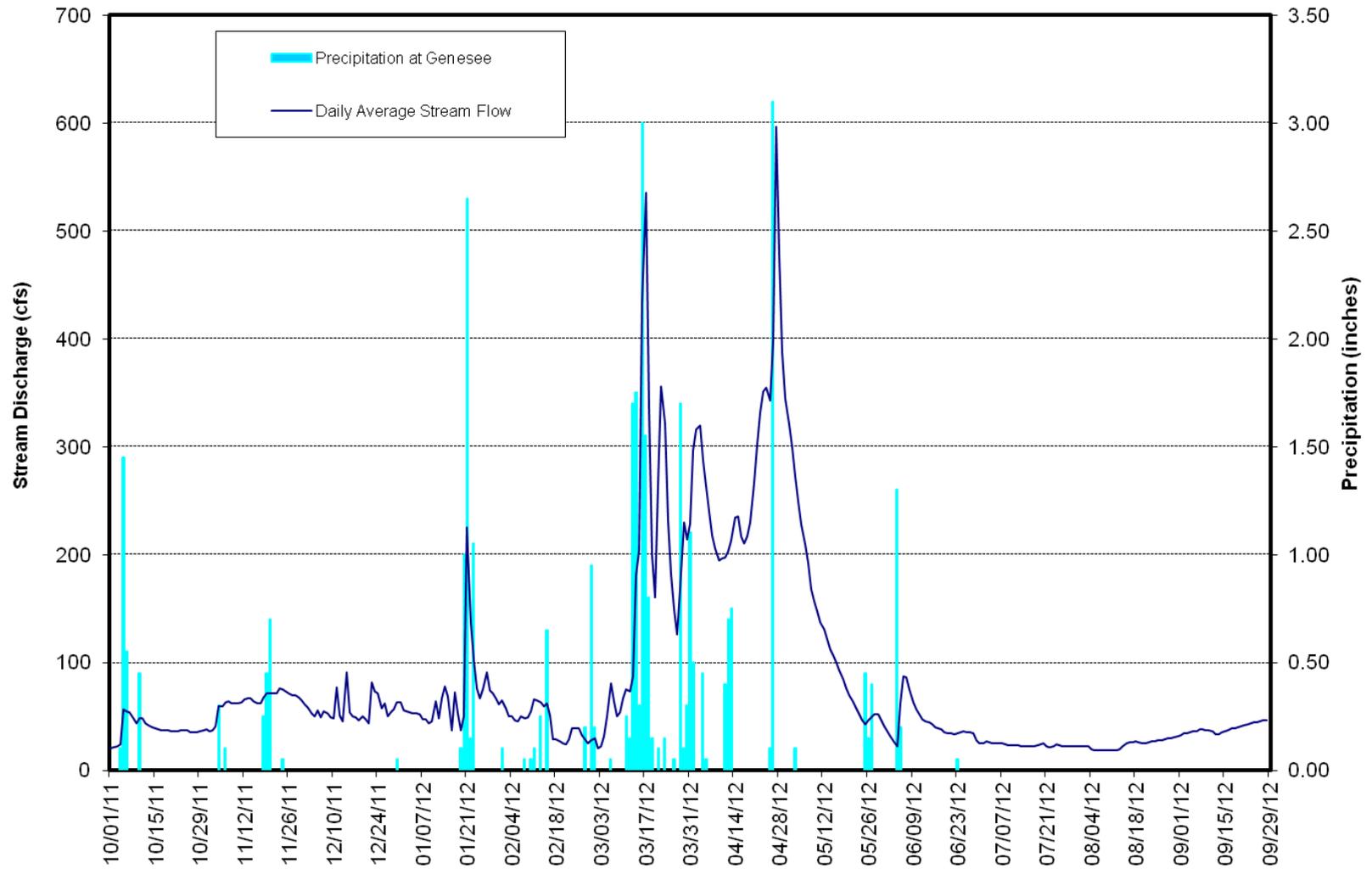


Figure 17: Indian Creek at Flourney Bridge Hydrograph 2012WY

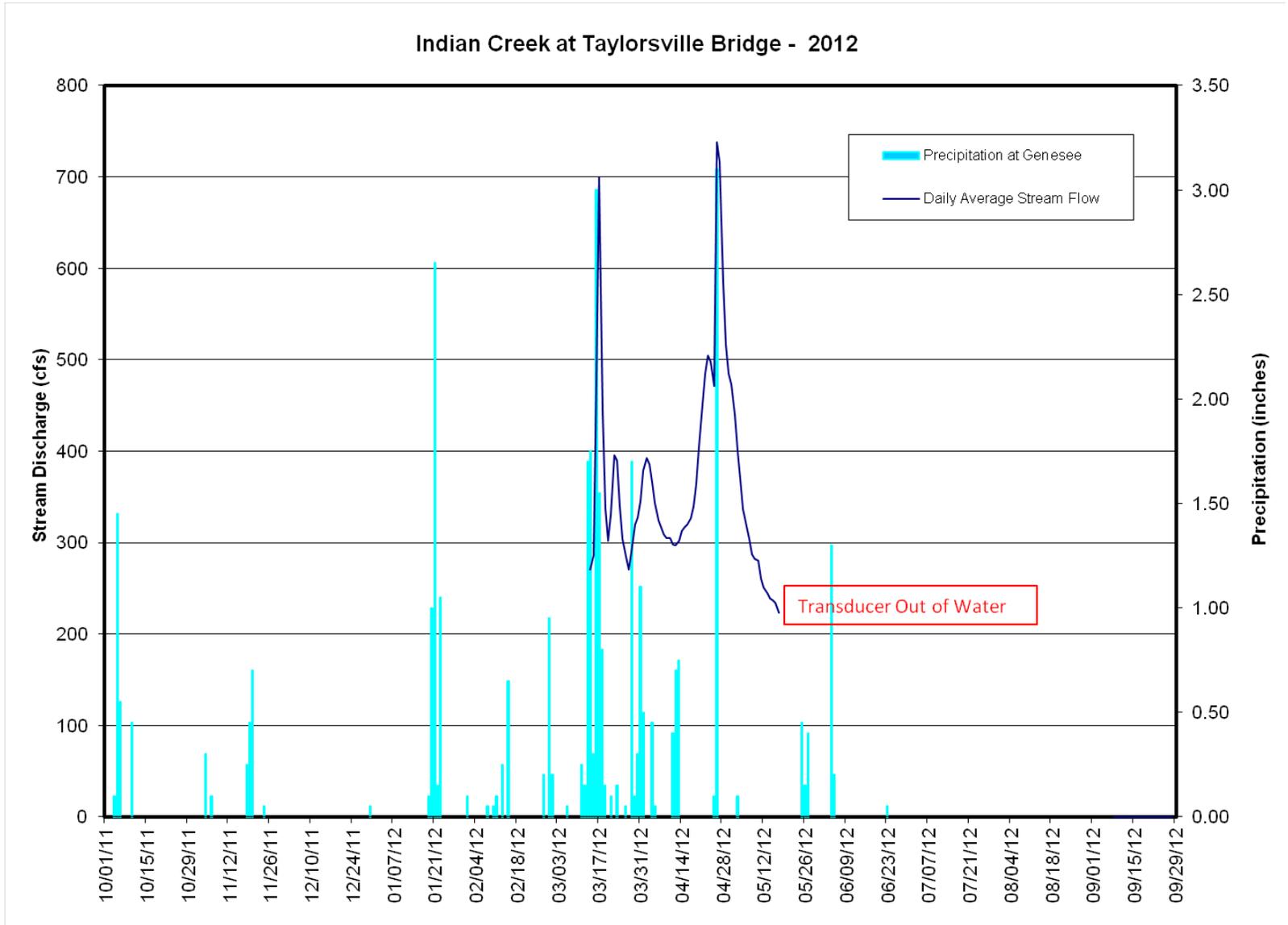


Figure 18: Indian Creek at Taylorsville Bridge Hydrograph 2012WY

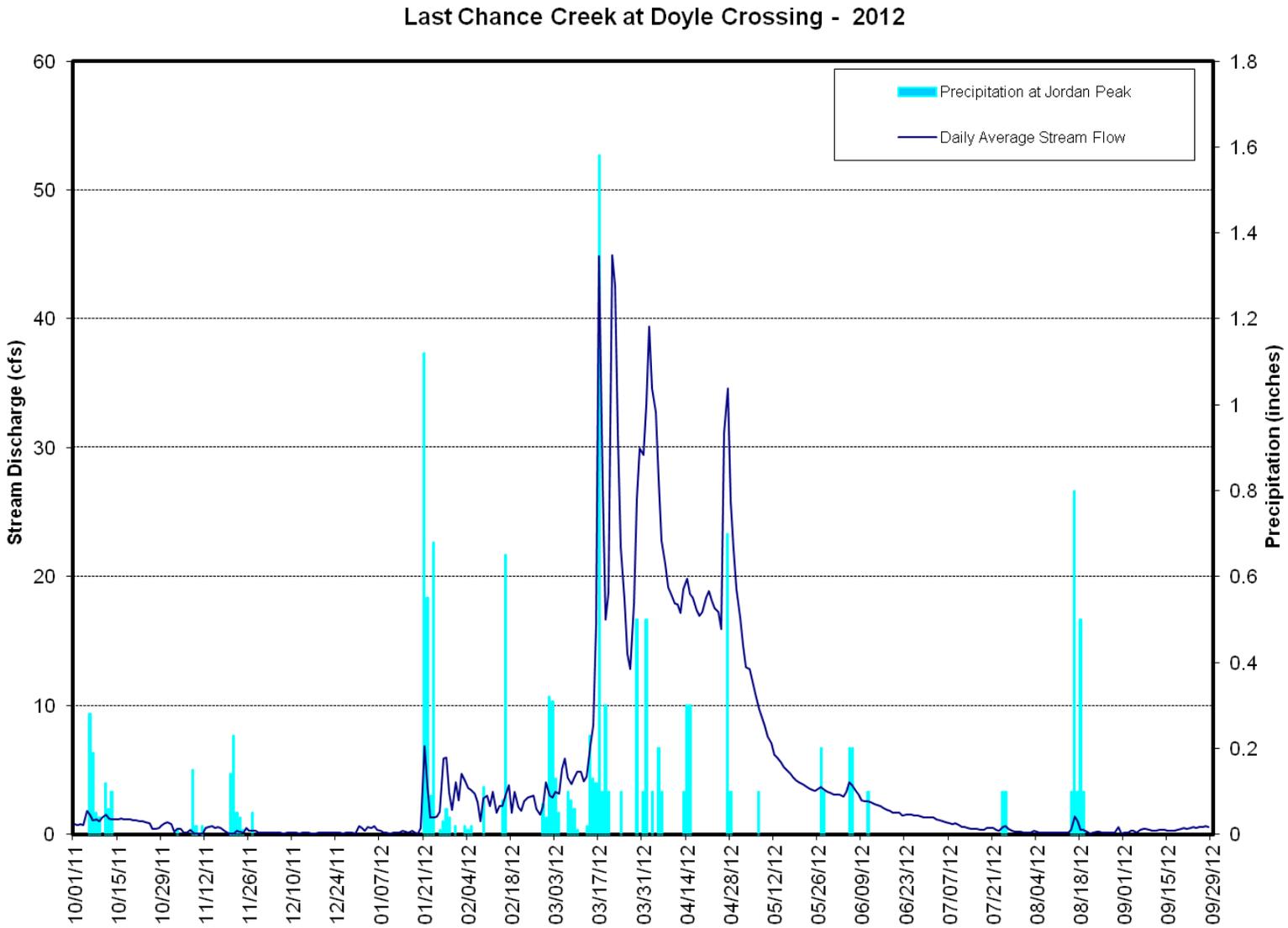


Figure 19: Last Chance Creek at Doyle Crossing Hydrograph 2012WY

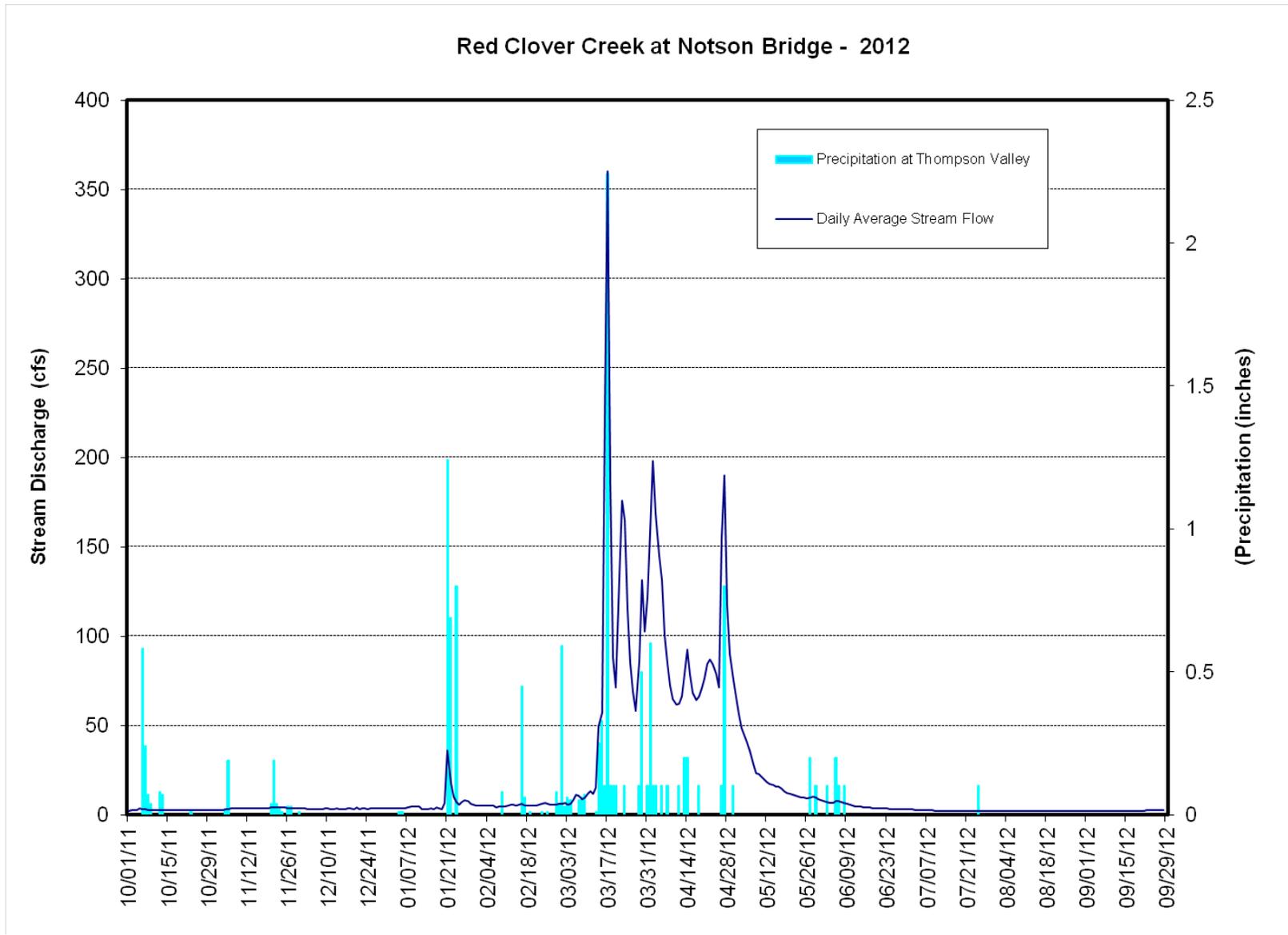


Figure 20: Red Clover Creek at Notson Bridge Hydrograph 2012WY

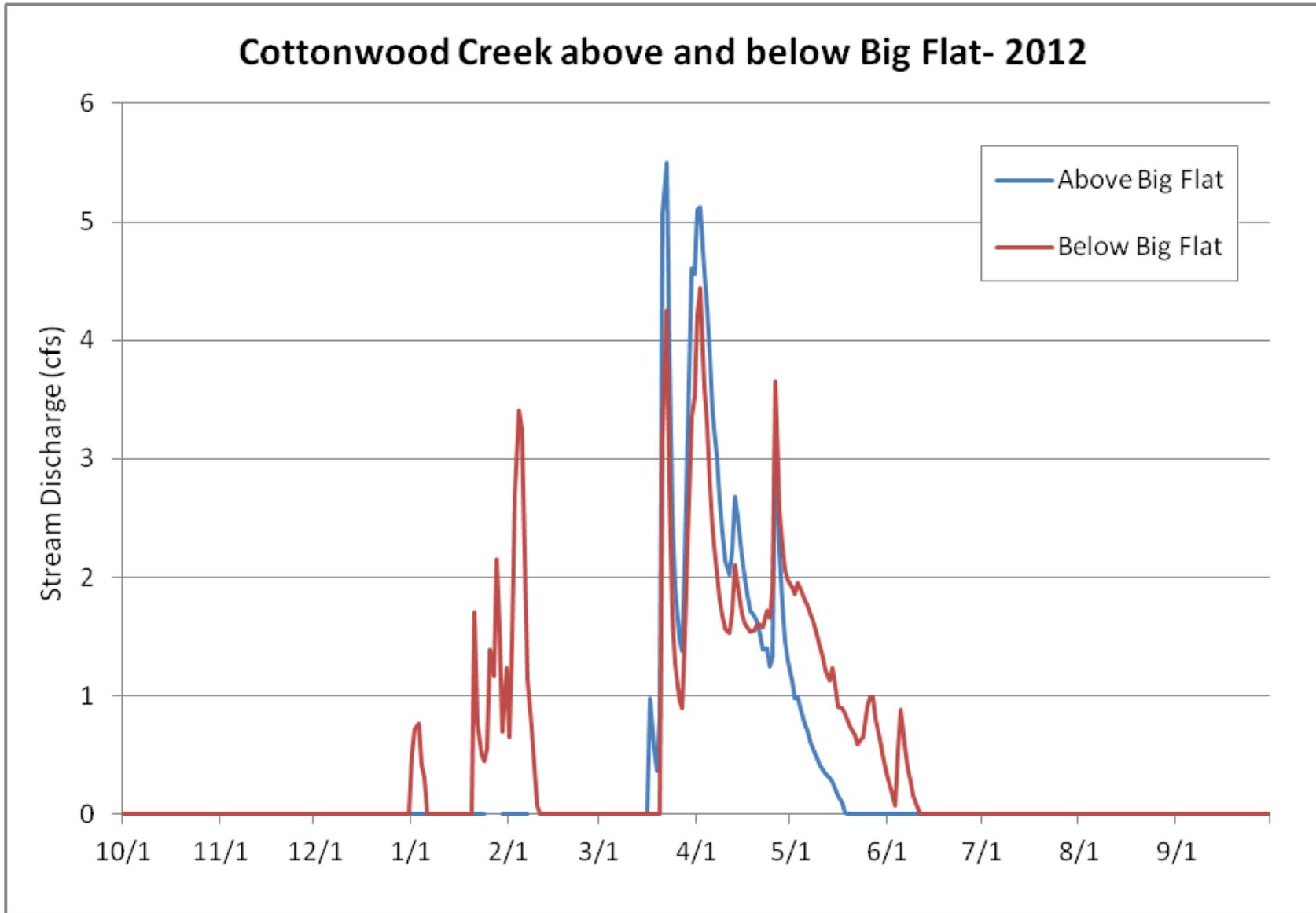


Figure 21: Cottonwood Creek above and below Big Flat Hydrograph 2012WY



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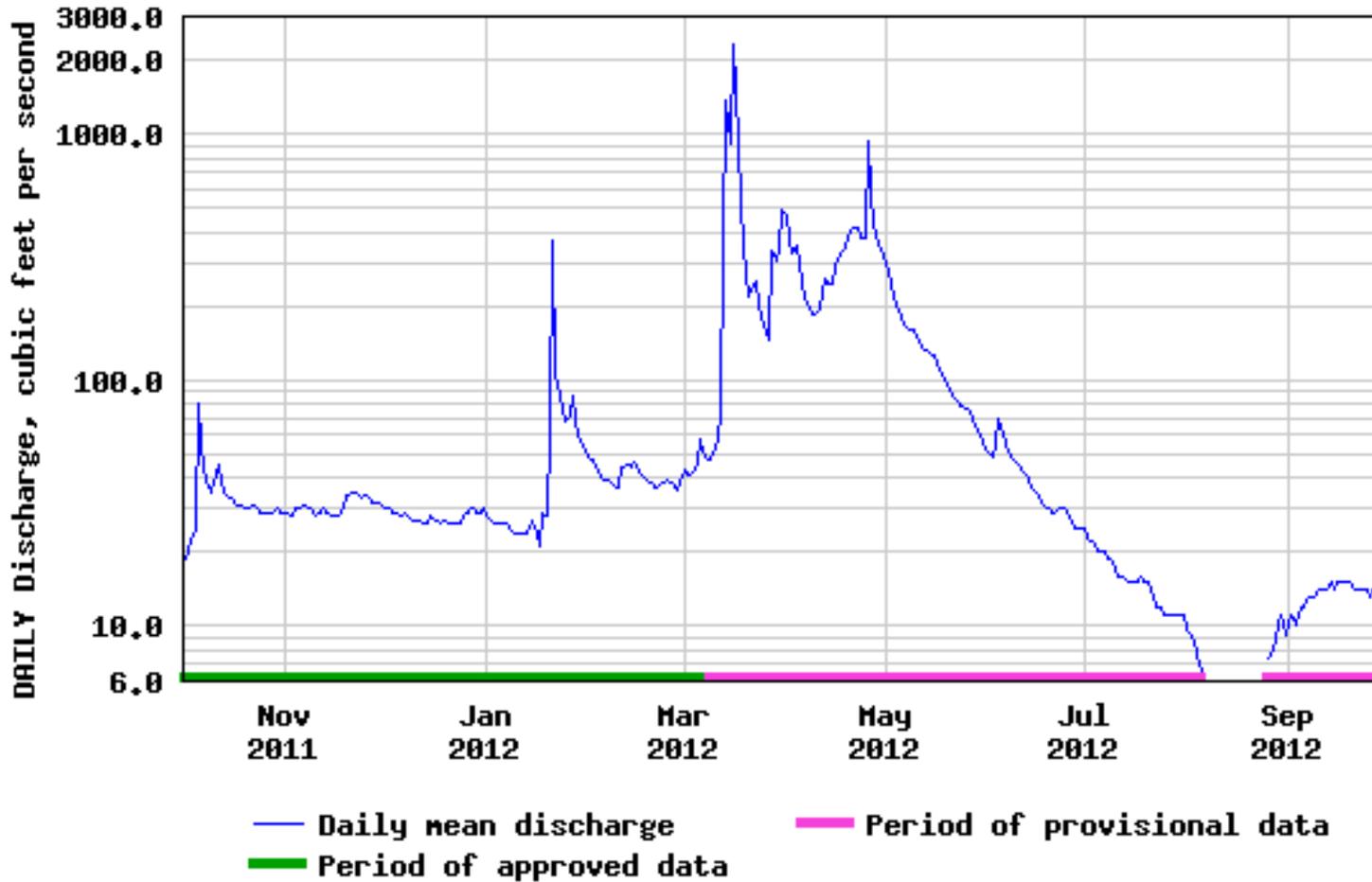


Figure 22: Spanish Creek at Quincy Hydrograph 2012WY

USFS Continuous Recording Station Hydrographs:

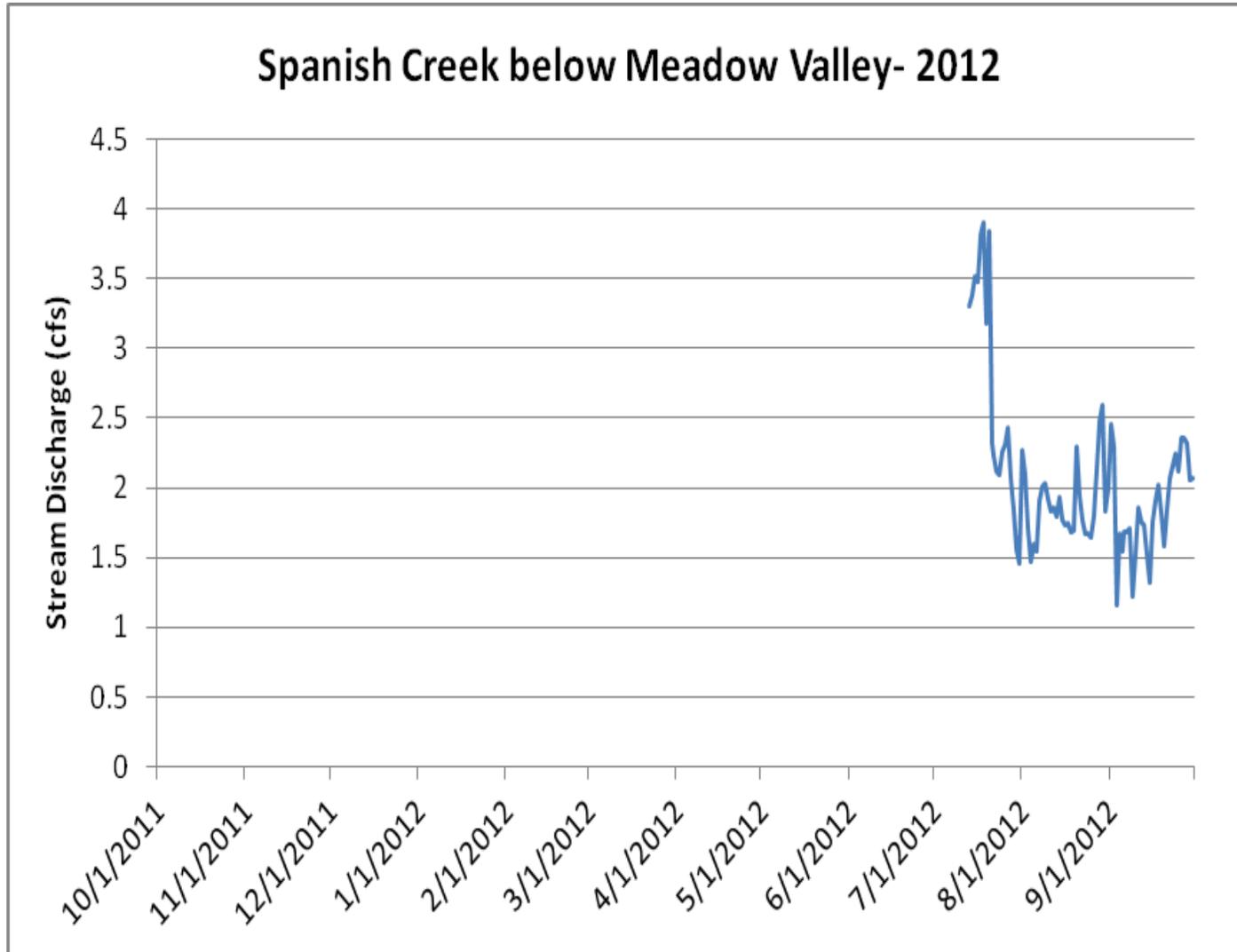


Figure 23: Spanish Creek below Meadow Valley Hydrograph 2012WY

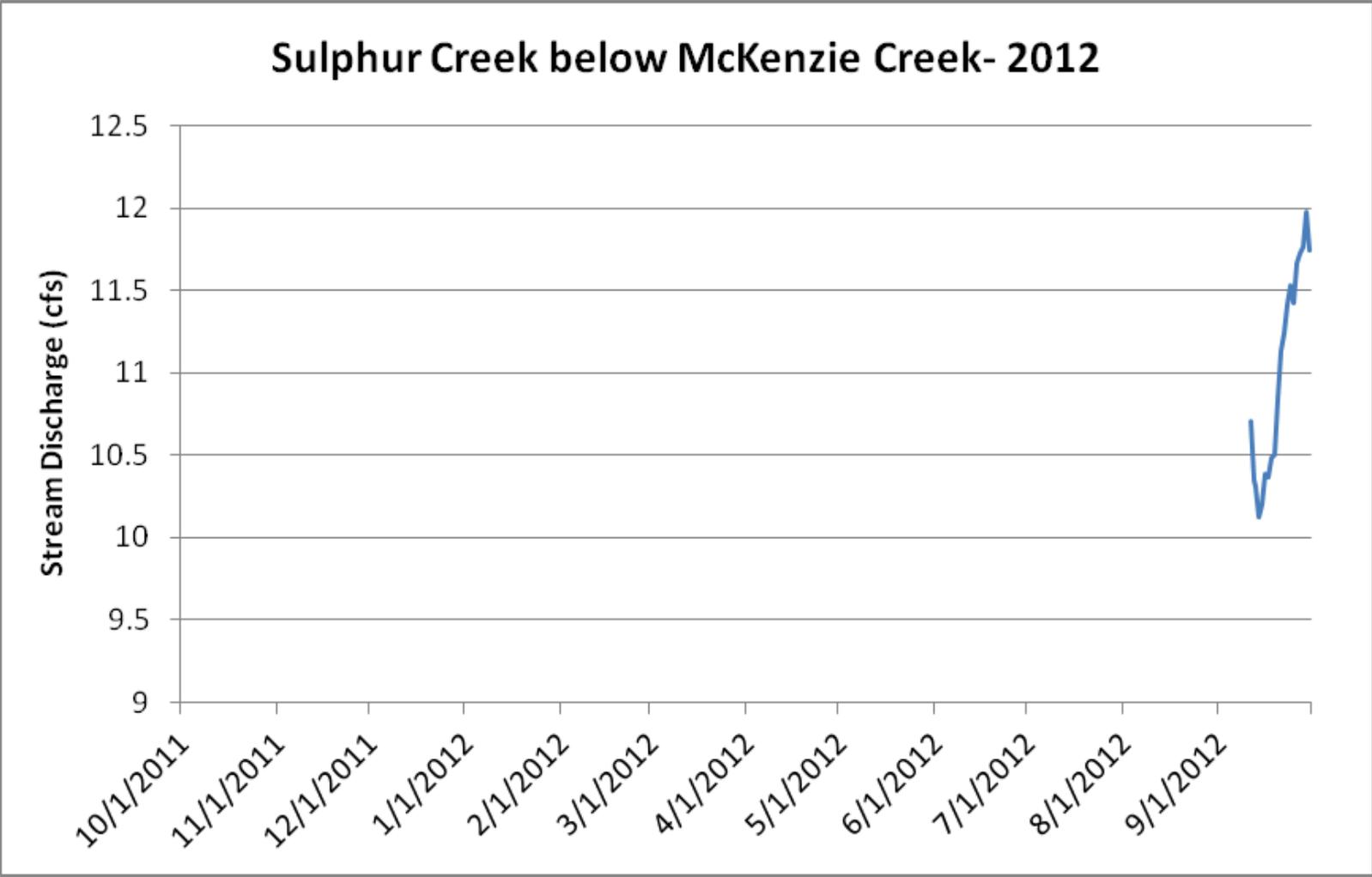


Figure 24: Sulphur Creek below McKenzie Creek Hydrograph 2012WY

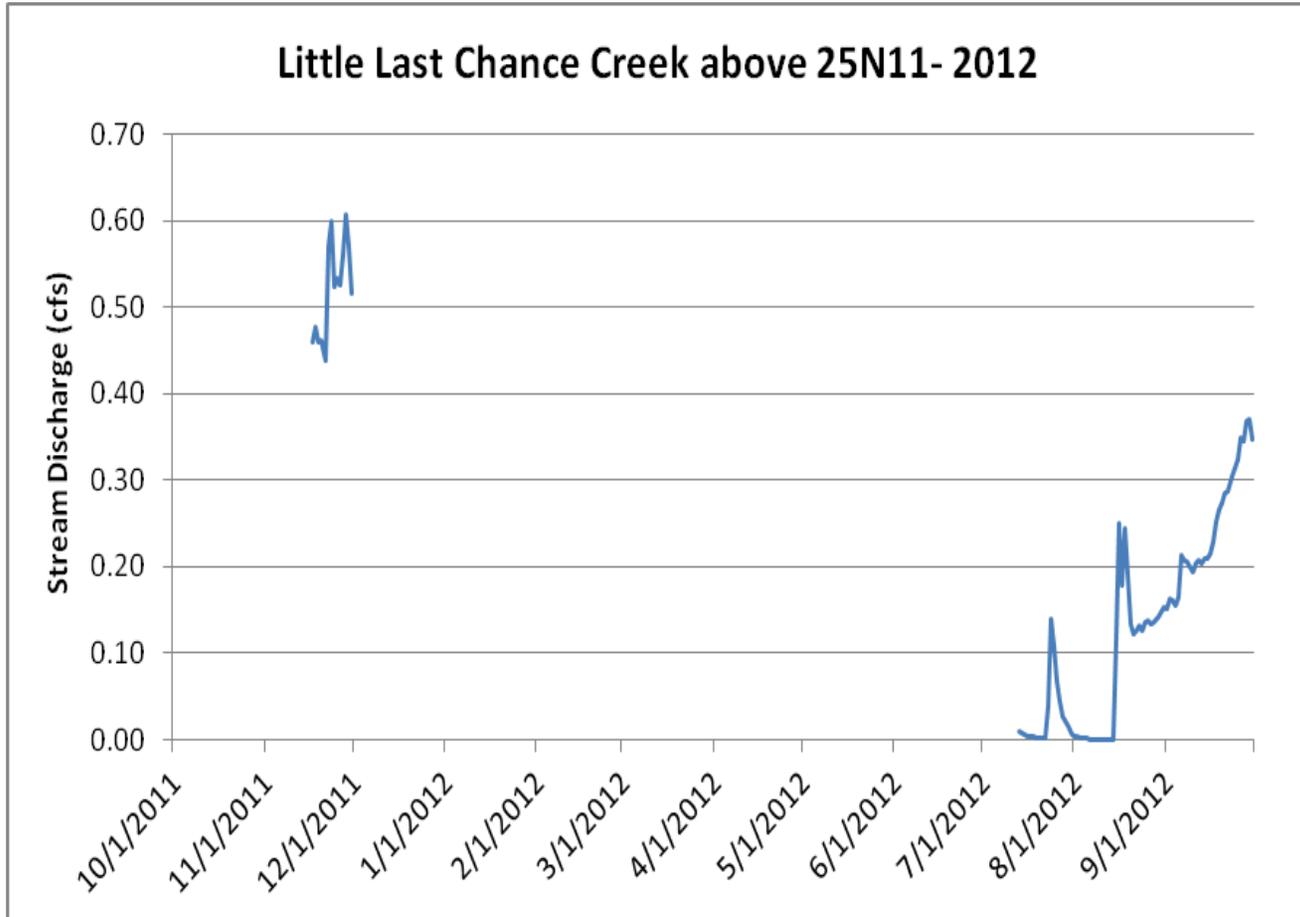


Figure 25: Little Last Chance Creek above 25N11 Hydrograph 2012WY

Charts 23-25 display daily average stream flow for the 2012 water year at the three new USFS continuous recording stations. The three stations were installed in November 2011. The loggers were collected in July 2012 for the initial download. It was discovered that the data collection rate was too excessive and took up all the memory on the loggers. The data gap from December 2011 through July 2012 on all the charts show the loss of data due to memory loss. It was also found that the sensors on Spanish and Sulphur creeks were faulty. The logger on Sulphur Creek was replaced in September and the logger on Spanish Creek was replaced in November 2012.

Conclusion

The 2012 Water Year was characterized by 79% of historic annual precipitation. While Last Chance and Lights creeks continued to be the most impaired streams for cold water fisheries that FRCRM monitors, improvement in maximum seven day average water temperatures and maximum summer diurnal fluctuation were seen on Last Chance Creek at Doyle Crossing over the last seven years of watershed monitoring data. While cause and effect are difficult to ascertain, such water temperature improvements may be attributed to over 10 miles of channel and almost 1,500 acres of affected meadows that have been restored by FRCRM on Last Chance Creek above Doyle Crossing. More restoration on Last Chance Creek above Doyle Crossing is planned for construction and we hope to see more improvements in summer water temperatures and baseflow on Last Chance Creek at Doyle Crossing.

There is a significant decrease in water at any given air temperature from pre- to post-project on Red Clover Creek at Notson Bridge. This decrease may be due to increased groundwater influence from project the Red Clover McReynolds and Red Clover Poco project construction, or the decrease could be due to other influences in the watershed like increased shading since 1997.

Unlike the improvements on Last Chance Creek and Red Clover Creek, we foresee little improvement in summer water quality on Lights Creek, particularly with sediment contribution from fire, yet there is still a downward trend on Lights Creek in number of days with maximum water temperatures above 70 degrees Fahrenheit. This decrease in water temperature above 70°F was also seen on Last Chance Creek at Doyle Crossing, Red Clover Creek at Notson Bridge, and Indian Creek at Flournoy Bridge.

Statistical analysis has not yet shown any significant difference in flows due to restoration, except on Cottonwood Creek above and below Big Flat. However, figures 10 and 12 show an increase in quantity (acre-feet) of water that passed by the Red Clover Creek at Notson Bridge and Last Chance Creek at Doyle Crossing gages in 2012 compared to 2002. The 2011 and 2012 water years were not analyzed for significance in Ken Cawley's 2011 report, but will be looked at in 2013.

Feather River Watershed

North Fork Feather River

East Branch North Fork Feather River

Middle Fork Feather River

Indian Creek

Spanish Creek

Greenhorn Creek

Greenhorn Creek (1991 & 2001) .75 miles, 18 acres

Reid/PNF Bank (2011) .07 miles

Dyrr Bank (2006) .11 miles

Elizabethtown (2002 & 2003) .3 miles, 7 acres

Kellet Bank (2008) .5 miles

Silver Creek (2008) .4 miles

Long Valley (2008) 2.1 mi/ 170 acres

Poplar Creek (1994 & 2003) .15 miles, 15 acres

Jamison Creek (1995 & 2005) .38 miles, 20 acres

Smith Creek (2007) .8 miles, 30 acres

Sulphur Creek

Sulphur Bank Stabilization (2009) .1 miles

Below McKenzie

Rapp-Guidici (2007) .4 miles, 13 acres

Boulder Creek (2008) .6 miles, 17 acres

Humbug-Charles (2004) .5 miles, 60 acres

Carman (2001 & 2002) 2.5 miles, 245 acres

Little Last Chance (2007) 5 miles, 750 acres

Above 25N11

Rowland (1997) 2 miles, 50 acres

Indian Creek

Wolf Creek (1989 & 2002) 2.6 miles, 29 acres

Lights Creek (CRS)

Hosselkus Creek (2002-2006) 1 mile, 60 acres

Ward Creek (1999) 1 mi./165 acres

Red Clover Creek

@ Notson Bridge

Bagley (1996) .26 miles, 10 acres

Poco (1986) .23 miles, 20 acres

Red Clover Poco (2010) 2.5 miles, 160 acres

Red Clover McReynolds (2006) 4 miles, 350 acres

Red Clover Demonstration (1985) 1 mile, 70 acres

Noble (1990) .28 miles, 25 acres

Dixie Creek (2007) .38 miles, 12 acres

Dotta Canyon (1988) .5 miles, 50 acres

Boulder Creek (1997) .75 miles, 20 acres

Willow Creek (1996) .25 miles, 11 acres

Last Chance Creek

Doyle Crossing

Big Flat (1995 & 2004) 1 miles, 47 acres

Above & Below Big Flat

Stone Dairy (2001) .5 miles, 20 acres

Little Stony Creek (1996) .15 miles, 2 acres

PNF (2003-07) 585 acres
multiple project reaches include:
Ferris Flat (2003)
Ferris Creek (2003)
Ferris Fields (2007)
Alkali Flat (2002)

Dooley (2005) 1 mile, 80 acres

Million \$ Bridge

PNF (2002-05) 350 acres
multiple project reaches include:
Jordan Flat + Supplemental (2002+05)
Artray (2002)
Bird-Jordan (2002)

Last Chance Charles-Matley (2004) .4 miles, 80 acres

Below Meadow Valley

@ Ball Field Bridge

@ Deadfall Lane Br.

@ Taylorville Br.

@ Flournoy Bridge

@ DWR weir

● USFS Continuous Recording Station (CRS)

● FRCRM Continuous Recording Station