

Watershed Monitoring Report – Upper Feather River Watershed Water Year 2014



Low flow recording equipment at Taylorsville Bridge.

Prepared by Plumas Corporation
Quincy, CA
January 2015

Acknowledgements

Twenty-five years of cooperative watershed monitoring has involved many, many individuals and agencies. This report, and the entire series of annual watershed monitoring reports produced by Plumas Corporation is the result of work by many people dedicated to science-based natural resource management. Many thanks go to partner agencies and those employees who have gone above and beyond their agency's scope to work across jurisdictional boundaries and address landscape-scale monitoring, as well as to many private landowners, who have allowed access and data collection on their properties. Specifically, we would like to thank past and present employees of the Central Valley Regional Water Quality Control Board: Dennis Heiman, Ben Letton; PG&E: Larry Harrison, Donna Lindquist; California Department of Water Resources: Dave Bogener, Todd Hillaire, Kevin Pond, Eric Leister, Scott McReynolds and many others; California Department of Fish and Wildlife: Richard Flint, Amber Coates, Julie Newman; Plumas National Forest: Barry Hill, Joe Hoffman, Tina Hopkins, Antonio Duenas, Don Kozlowski; Natural Resource Conservation Service: Dan Martynn, Terri Rust, Dan Kaffer, Ceci Dale-Cesmat; University of California Cooperative Extension: Holly George and Mike DeLasaux; Meadowbrook Conservation Associates: Mike Kossow and Ken Cawley; Plumas Geohydrology: Burkhard Bohm. Many thanks, as well, to those who reviewed this year's report: Gia Martynn and Jim Wilcox.

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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
DG -	Data Gap
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

2014 Monitoring Report Summary

This report tiers to Feather River Coordinated Resource Management (FRCRM) and Plumas Corporation Feather River Watershed monitoring reports from 1999 through 2013. This and past reports include the effort of many partners, and the program would not be as effective without partner participation.

The 2014 Water Year (October 1, 2013- September 30, 2014) was a below-average water year; the third below-average year in a row, with the Feather River basin declared to be in extreme drought. Data from the California Dept of Water Resources report 63% of normal historic precipitation for the Northern Sierra Precipitation Eight Station Index; and nine of the ten precipitation stations typically used in this Monitoring Report also show an average of 63% of normal historic precipitation for the Feather River Basin. The water year was characterized by low precipitation through January, and most of the precipitation occurring as rain in February through April (see Figure 2). Summer air temperatures were average.

This report includes data from continuous recording flow stations operated by Plumas Corporation, and Plumas National Forest, Beckwourth Ranger Station (USFS or PNF).

Most important findings in this monitoring report:

- Despite high air temperatures and low stream flow, water temperatures did not increase at all sites, presumably due to groundwater influence.

Data Issues

Scant monitoring resources have required Plumas Corporation and partners to prioritize which stations would be continued into the future. Annual costs for operating each station are approximately \$3,500. 2014 was the first full year that a Monitoring Coordinator position was not funded. Station operation and reporting were conducted by staff in addition to other duties. Without additional funding sources identified in 2015, this will be the last annual Watershed Monitoring Report prepared by Plumas Corporation staff.

- The Lights Creek and Million Dollar Bridge stations have been removed.
- After moving the sensor at the Taylorsville station, 2014 was the first year with low flow data from this site. A ditch had to be hand-dug through sediment from the main channel flow to the sensor.
- Wolf Creek: Beaver activity at this site continues to confound efforts to correlate stage readings with flows.

- A lack of high spring flows resulted in inadequate high flow calibration measurements; therefore, high flow data should be considered estimates.

About the Upper Feather River Watershed Monitoring Program

The FRCRM began in 1985 as a partnership of public agencies, private sector groups, and local landowners, 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 channels in alluvial settings. 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.

One of the values of the monitoring program lies in the longevity of the data. In the face of structural changes of the partnership, those involved in this large scale watershed monitoring effort continue to work together and contribute resources to the program because of the usefulness of the data in managing water resources and aquatic/riparian ecosystems.

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 Plumas Corporation's website at plumascorporation.org. The monitoring network was installed in 1999 and data have been collected from 2000-2014.

Initial funding for the watershed monitoring program was provided to Plumas Corporation through a Clean Water Act 319(h) grant (Aug 1998 to Dec 2000). Subsequent funding sources have been: the California Surface Water Ambient Monitoring Program (SWAMP); the Plumas Watershed Forum; US Forest Service Resource Advisory Committee, Title II funds; the Rose Foundation; the Norcross Foundation; and Esri has contributed GIS software. In addition, various restoration project monitoring budgets have supported the network. Partner agencies (Plumas National Forest, University of California Cooperative Extension, California Department of Fish and Wildlife (previously Calif. Dept. Fish and Game), Feather River College, California Department of Water Resources, Central Valley Regional Water Quality Control Board, and the Natural Resource Conservation Service) have provided valuable contributions such as data collection, data, equipment, and review.

Monitoring Program Description

Three of the main HUC 3 (Hydrologic Unit Code 3) subwatersheds of the Feather River basin are covered under this monitoring program (South Fork Feather River and West Branch Feather River are not included):

- Indian Creek
 - Spanish Creek
 - Middle Fork Feather River (HUC #18020123)
 - North Fork Feather River (HUC #18020121)
- } East Branch North Fork Feather River (HUC #18020122)

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 (re-installed in Nov 2013)

The following table summarizes the history of Continuous Recording Stations operated by Plumas Corporation and other selected stations. Flow stations operated by other agencies that are no longer operational are not included. Weather stations are not included in the table.

Table 1. Continuous Recording Station Data Histories

Continuous Recording Station Flow Data															
	Water Year = 10/1 through 9/30 DG = Data Gap All = All year-round data														
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Indian Creek at DWR Weir	Start 11/5	All	DG: 2/4-2/6	All	All	All	All	DG: 6/1-9/30	DG: 9/10-9/30	DG: 10/1-12/9	DG: 8/24-9/30	Start 10/7	All	All	DG: 12/15-2/5
Indian Creek at Flournoy Bridge	Start 11/5	All	DG: 10/4-10/9	DG: 8/15-9/30	Start 12/5	DG: 10/6-10/16, 6/7-9/30	DG: 10/1-12/18, 3/1-9/30	DG: 10/1-2/8, 2/14-3/6, 4/9-4/11, 5/7-8/7	All	All	DG: 7/31-9/30	DG: 11/12-7/28	All	All	All
Indian Creek at Taylorsville (high flow station only until 2014)	Data from 1/16-5/29	none	Data from ~12/31-5/7	Data from ~12/14-6/8	Data from ~12/6-5/12	Data from ~1/27-6/11	Data from ~11/23-7/7	none	Data from ~1/5- 5/21	Data from ~1/24- 6/9	Data from ~2/16-6/9	Data from ~12/4-7/11	Data from 3/14-5/17	Data from 11/30 - 4/21	Flow data starts 1/4; Temp data starts 11/4
Last Chance at Doyle Xing	DG: 11/19-1/6, 2/25-3/17	All	All	All	DG: 9/5-9/30	DG: 10/1, 1/7-1/18	All	All	All	All	All	DG: 11/3-7/17	All	All	All
Last Chance at Million \$ Br (high flow station only)					Data from 12/9-5/27	none	Data from ~11/8-5/24	Data from ~12/10-5/9	Data from ~1/23- 6/1	Data from ~1/29-5/13	Data from ~1/13- 6/8	Data from ~12/6- 7/10	non	Data from 11/26-6/23	station discontinued
Lights Creek	Start 12/28	DG: 7/30-9/30	DG: 8/12, 8/14-9/11, 9/18-9/23, 9/29-9/30	DG: 10/1-10/11, 10/25-10/23	All	DG: 12/22-1/11, 3/30-9/30	DG: 1/24-2/3, 6/10-7/7, 7/20-9/30	DG: 10/1-2/9, 5/9-8/7	DG: 7/3, 7/7-7/10	All	All	All	All	Data from 10/1 thru 4/30	Discontinued since 4/30/13

Red Clover Creek at Notson	Start 10/23, DG: 7/5-8/10	All	DG: 11/27-5/1	All	All	All	DG: 10/8-11/18	All	error-calculated flow only	Start 12/10	Start 10/13	All	All	10/1-3/14 only, then sensor error	DG: 10/1-1/27
Wolf Creek at Main St Br	Data from 12/21-7/19	DG: 10/1-11/13, 1/10-1/12, 4/5-4/18, 4/22-5/3, 8/20-8/23	Start 2/20	DG: 12/16, 12/28, 1/13-1/14, 3/15	DG: 2/17-2/19	DG: 11/1-11/3, 9/3-9/30	All	All	All	taken out & moved to Ballfield Bridge	—	—	—	—	
Wolf Creek at Ballfield Br										Start 11/09	All	All	DG: 3/30	All	All
Spanish Creek				DG: 12/14-12/16, 12/27-12/29, 8/4-8/26	All	All	DG: 10/1-11/10	none	Start 10/26	DG: 5/29-7/30	Discontinued 12/21. See USGS gage at QCSD plant.	—	—	—	—
Sulphur Creek						Start 3/9	DG: 11/9, 1/1-9/30	station discontinued							
Sulphur DS of McKenzie (PNF)													Installed July	data thru July 18	All
Little Last Chance (PNF)												Installed Nov	DG: 10/1-7/12	data thru July 18	DG: 11/7&8

correlate with observations near the station.) This report includes data from five annual precipitation gages, located on the eastside of the watershed and operated by DWR.

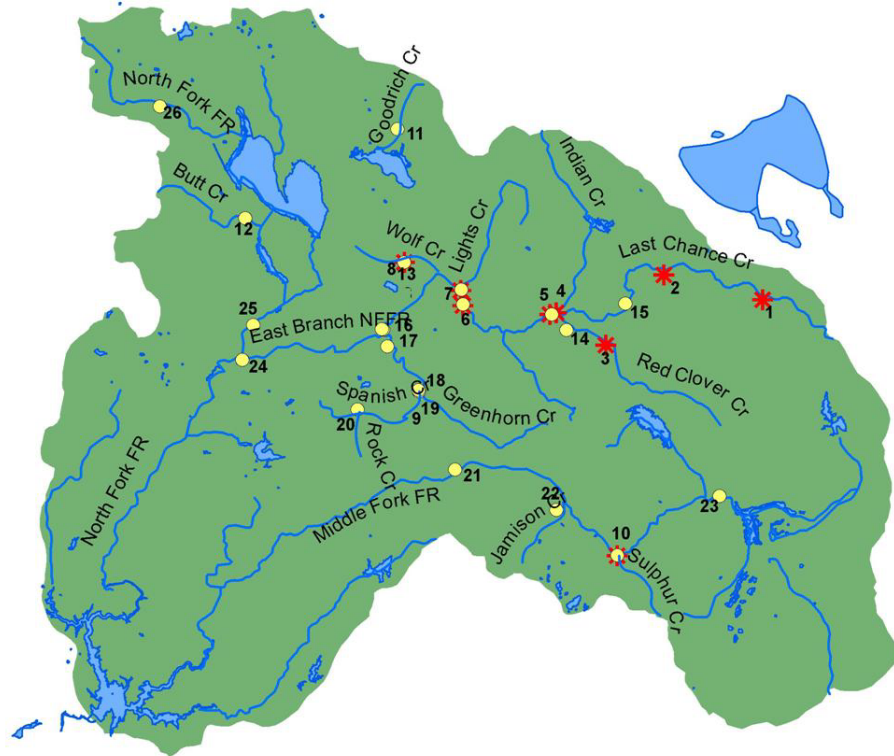
USFS Stream Flow Stations

The USFS installed three continuous recording flow stations in the Feather River watershed in 2011. These stations are located on Little Last Chance Creek above Lookout 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 are operated and calibrated by the Plumas National Forest, Beckwourth Ranger District.

Table 2. Watershed Areas above Plumas Corporation Continuous Recording Stations.

Watershed Areas above Plumas Corporation 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 Flournoy Bridge	281,132
Indian Creek at Taylorsville	343,193
Lights Creek at Deadfall Bridge	67,722
Wolf Creek at Ball Field Bridge	31,945

**Figure 1. Plumas Corporation's
Continuous Recording &
Monitoring Reach Locations. All
STATIONS**



* 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 @ Flournoy 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 @ Dyr 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 3. Upper Feather River Watershed Monitoring Sites

Map #	Monitoring Site by Subwatershed	Monitoring Type	Yrs Surveyed/ of Operation
	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 @ 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)	12/11- 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 (PlumasCorp) blw Indian Falls (DWR)	MR & CRS (DWR)	99, 01, 03, 11/ 07-present
13	Wolf Cr @ Main St Bridge in Greenville moved to:	CRS	2000-2009
13	Wolf Cr @ Ball Field Bridge in Greenville	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 & 2007-present
5	Indian Cr @ Flournoy (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

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

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

	McClellan Cr	MR (DWR)	97, 01, 05, 10
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Table 3 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
	Little Last Chance	CRS (USFS)	Nov 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 McKenzie 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

2014 Monitoring Program Findings

Climatic and Watershed Context

New to the watershed monitoring report in 2013, and included again this year, is a comparison of the “Percent of Historic Average annual precipitation for the entire Feather River Basin from CDEC” column in Table 4, to annual precipitation (1998-2013) from five rainfall storage gages (aka rain tubes) operated by DWR located in the eastern portion of the Feather River watershed. The analysis confirmed suspicions that the ten stations used to describe average annual precipitation in the entire Feather River basin do not always reflect average annual precipitation on the east side of the watershed, where a large part of the meadow restoration effort has been focused. There also appears to be a decrease in the running average from 1998 to 2014 at the eastside stations.

Table 4. 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*	Percent of Historic Average annual precip for five eastside stations**	Total annual precip (inches) in Genesee (Wilcox data only)***	Summer Average Air Temperature °F [†] June 1-Sept 30
1996			59.25	
1997			61.6	
1998	144%	124%	60.9	
1999	99%	109%	47.2	
2000	101%	84%	43.3	61.4
2001	56%	41%	21.2	63.0
2002	77%	73%	33.3	62.3
2003	111%	79%	50.7	63.2
2004	83%	77%	41.15	61.7
2005	109%	80%	45.5	60.5
2006	154%	125%	66.25	62.3
2007	60%	62%	31.05	61.5
2008	68%	68%	25.4	62.9
2009	84%	97%	38.05	62.6
2010	101%	83%	33.85	61.4
2011	142%	141%	56.60	64.9
2012	79%	64%	33.85	63.4
2013	81%	93%	43.6	62.2
2014	63%	49%	34.5	64.7
AVERAGES	Average annual = 45” (40-50 yr avg as reported on DWR Quantitative Precipitation Forecasts)	Averages Vary: 21.38” running avg of all 5 stations in 1998 to 20.0” running avg in 2014	Column average = 43.5”	Column average = 62.5°F

* Averages derived by DWR from all stations reporting water year precip and averages in the watershed. The ten stations in the Feather River watershed are: Plumas Eureka Park (PLE), Sierraville (SRR), Vinton, Portola(PRT), Chester (CHS), Strawberry Valley, Brush Creek (BCM), Greenville, Quincy, and Nicolaus. In 2012, 7/10 stations reported averages (Plumas Eureka Park, Greenville, and Nicolaus did not report). In 2013, all stations but Nicolaus are included in the 81% of average reported above. In 2014, only PLE, SRR, BCM, CHS, PRT are included in the average.

** *The values in the Genesee Precip column are unrelated to the Percent of Historic Average Annual Precip values.

† Average derived from DWR weather stations at Antelope Lake, Doyle Crossing, Grizzly Ridge, and Quincy. Data are missing from Doyle Crossing in 2000, 2012 & 2013; Grizzly Ridge in 2001 and '14; and Antelope Lake in 2007 & '13. In 2013 Plumas Corp's Notson Bridge CRS was added. 2014 figure includes all but GRZ.

**The five eastside annual rainfall storage gages and installation years are: Red Clover Valley(1965), Last Chance Cr(1969), Clarks Cr(1959), Upper Indian Cr(1969), and Little Last Chance Cr(1960)

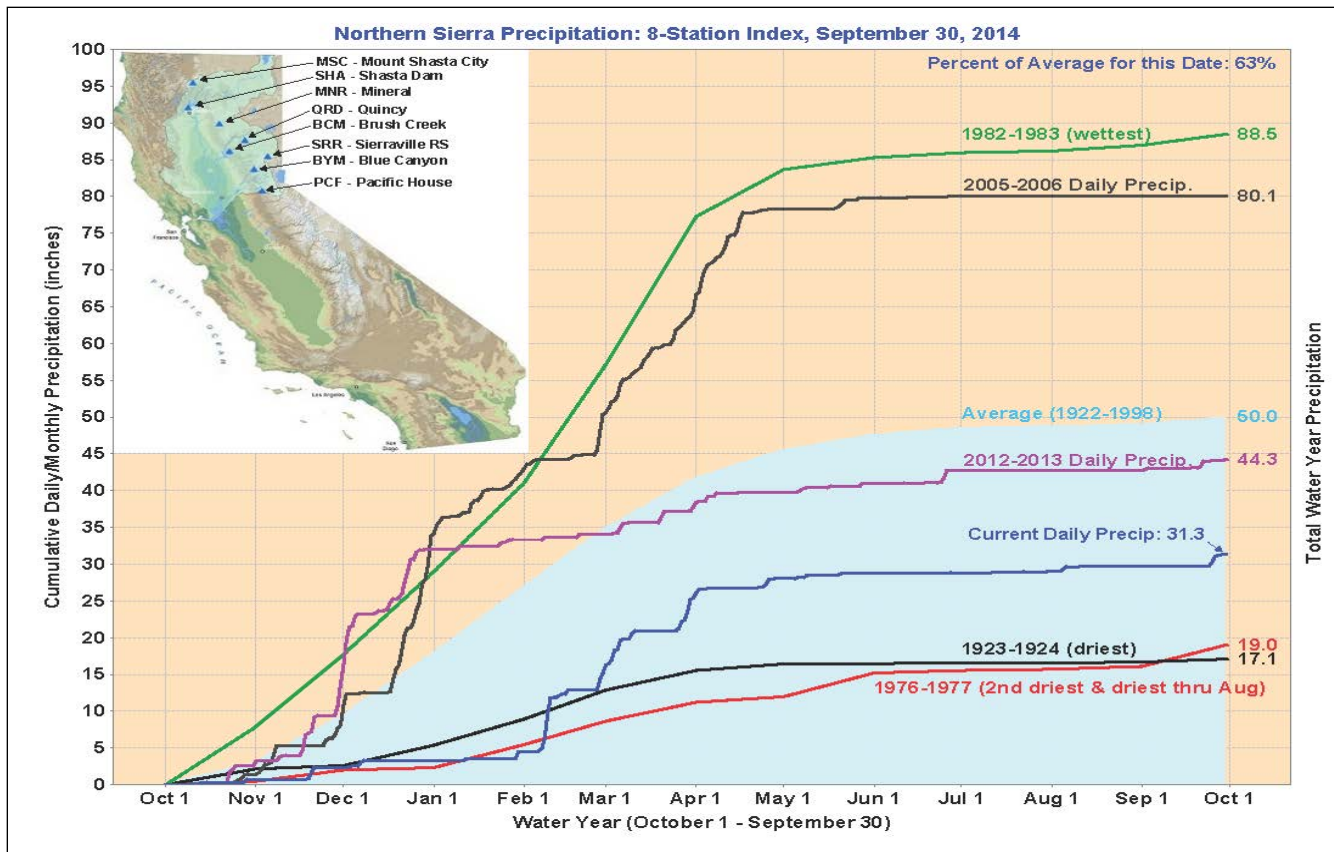


Figure 2. Source: http://cdec.water.ca.gov/cgi-progs/prevprecip1/PLOT_ESI DWR Historic Precipitation for the Northern Sierra. 2014WY in dark blue. Note that these stations are different than the stations reporting averages for the Feather River watershed in Table 4. Eight Station Index includes: Mt Shasta City, Shasta Dam, Mineral, Quincy, Brush Creek, Sierraville Ranger Station, Blue Canyon, Pacific House.

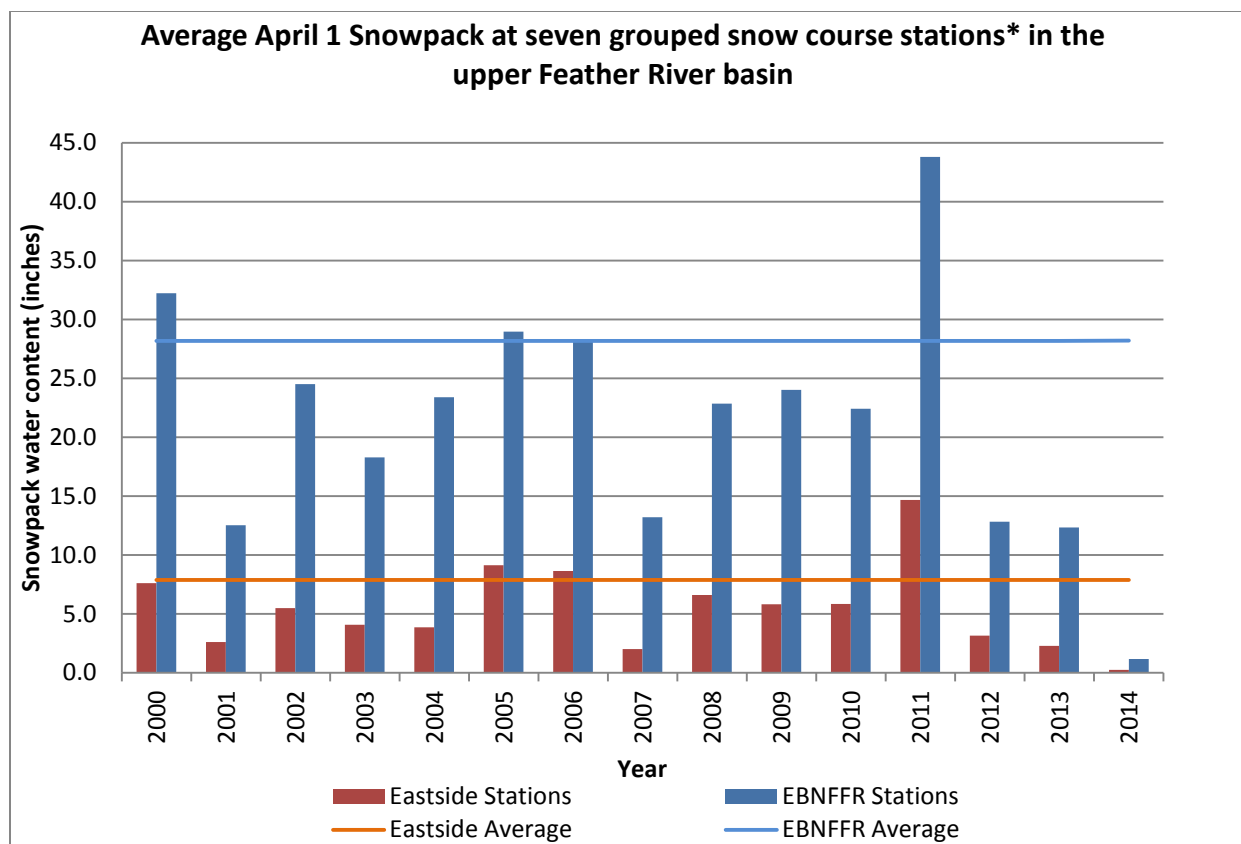
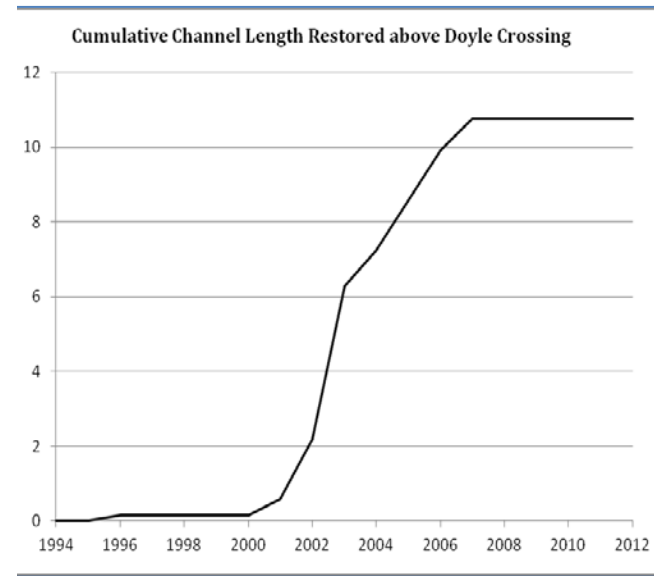
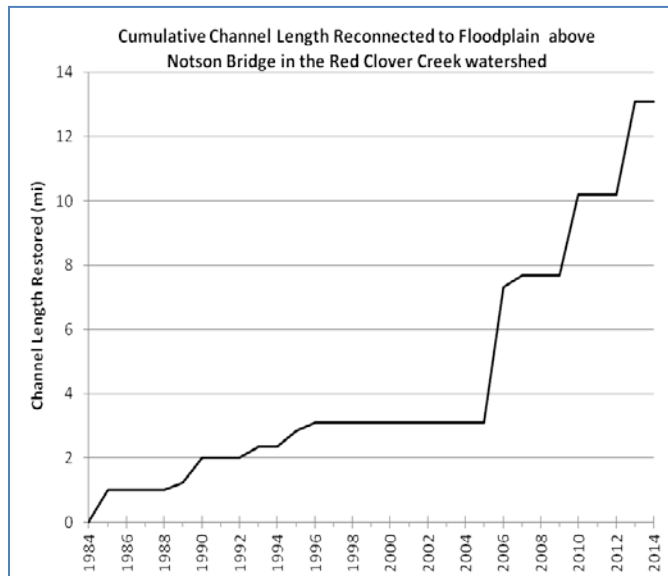


Figure 3. Average April 1 snowpack at stations throughout the upper Feather River. *Four eastside stations are Abbey, Rowland, Antelope Ridge, and Frenchman Cove, installed 1950-1963. Three East Branch North Fork Feather River (EBNFFR) stations are Kettle Rock, Mt. Hough and Grizzly Ridge, all installed in 1965.

New to the report last year is April 1 snowpack water content data (Figure 3 above). These data were added to provide additional information on annual precipitation data. The April 1 snowpack water content gives some indication of the snow pack available for snowmelt run-off. The average lines in Figure 3 are the averages for the period of record for those groups of stations. Since 2000, for both groups of stations, most years are below average - perhaps indicating a decline in the average.

Restoration Activity Context

Figures 4 a and b below display when restoration activities occurred on Red Clover Creek (4a) above Notson Bridge, and Last Chance Creek (4b) above Doyle Crossing. Continuous recording flow stations were installed in 2000. On Red Clover Creek, while work had been completed prior to 2000, 1996-2005 can be used as the pre-project condition, since no work was accomplished from 1996 through 2005, and most of the work was accomplished after 2005. Project work on Last Chance Creek began shortly after the installation of the Doyle Crossing flow station, resulting in less pre-project data available for comparison.



Figures 4a (Notson) and 4b (Doyle). Depiction of cumulative channel length restored with floodplain reconnection over time in the Red Clover Creek (4a), and the Last Chance Creek (4b) watersheds.

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 5-8 display water temperature from Plumas National Forest (PNF) and Plumas Corporation Continuous Recording Stations. For chart consistency, the discontinued Lights Creek station data are replaced with Taylorsville Bridge data. Indian Creek at Taylorsville was moved in 2013, so that 2014 was the first year that this station was able to record low flow data.

Maximum Weekly Average Temperature (MWAT)

Figures 5a and 5b display the running seven-day average of daily maximum water temperatures for the summer months (May 1-Sept 30) in 2014. While water temperatures detrimental to trout (above 70°F) are reached in eight of the nine stations in Figures 5a and b, Indian Creek at Taylorsville is the first station in the season to reach high temperatures. For such a warm station, it also shows an early seasonal decrease to cooler temperatures. The early insolation and later hyporheic exchange (mixing of shallow groundwater and surface water) on the extensive gravel bars just upstream of the station may contribute to this. Similarly, locations and years with less groundwater influence can achieve warmer temperatures than those with more groundwater influence. That is why years with higher precipitation can have warmer water temperatures - the diminished influence of groundwater.

The Figure 6 series (a, b, c) display the one-time highest value of the seven day average of daily maximums. Figure 6a displays all years since 2000 for Indian Creek Stations. Figure 6b displays only the subset within Genesee, to visualize the contribution of water temperatures coming into Indian Valley. Figure 6c shows the same parameter for just 2014, and includes the PNF stations, allowing a comparison across the watershed. Note that air temperature increased, and precipitation decreased from 2013 to 14. Without the groundwater influence, maximum daily water temperatures would be expected to increase. The Doyle and Notson stations showed a decrease in max temperatures from 2013 to 14. Flounoy and DWR stayed the same, and Wolf increased, with no 2013 data for Tville nor the PNF stations. Most stations continue to show temperatures too warm for good trout production. The decrease at Doyle and Notson only corroborates the 2013 statistical analysis that showed a decrease in maximum water temperatures under the post-project conditions, compared to pre-project, with no difference at the other sites.

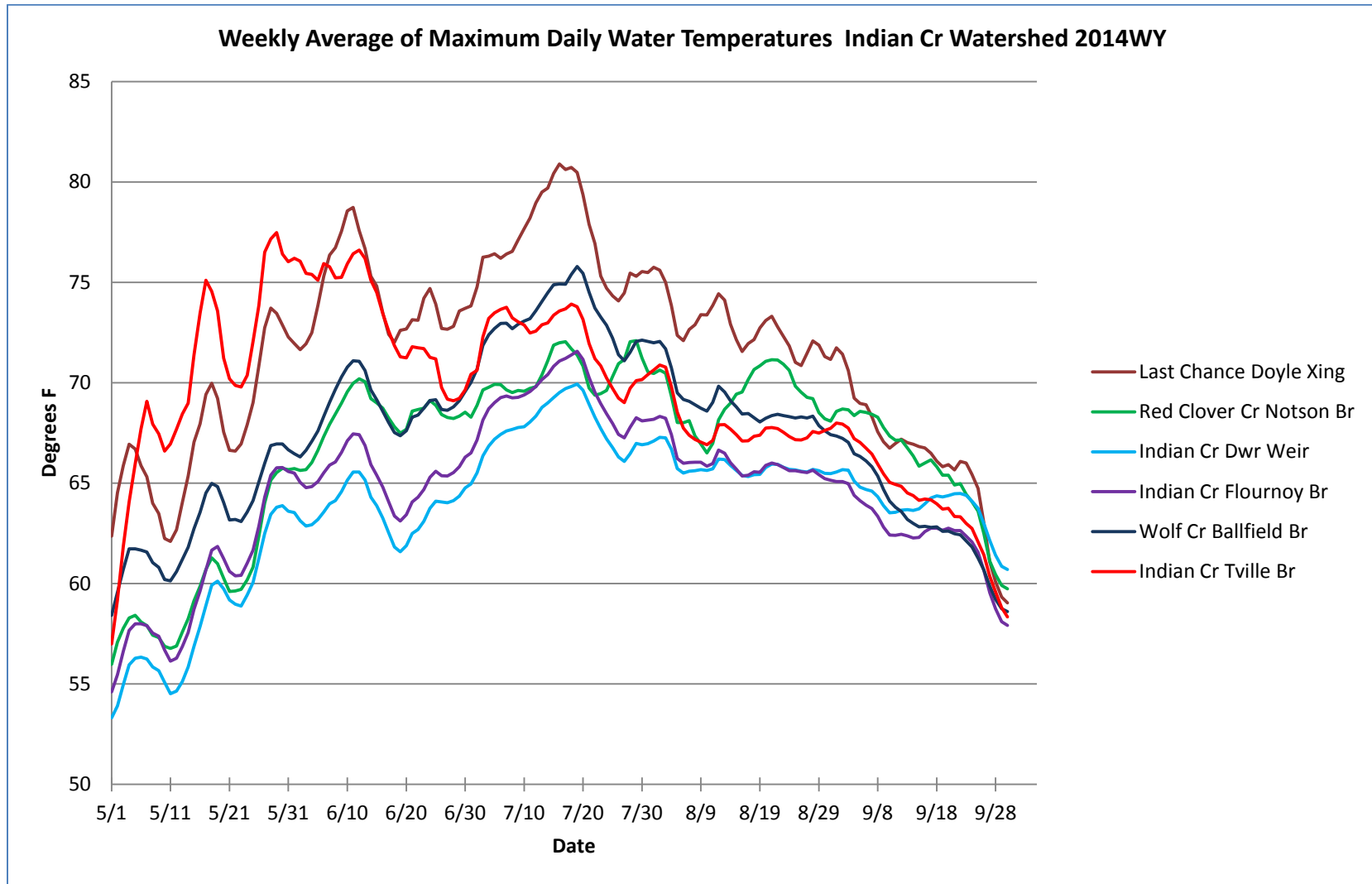


Figure 5a. 2014 Seven Day Average of Daily Maximum Water Temperatures at Indian Creek Watershed stations for summer season.

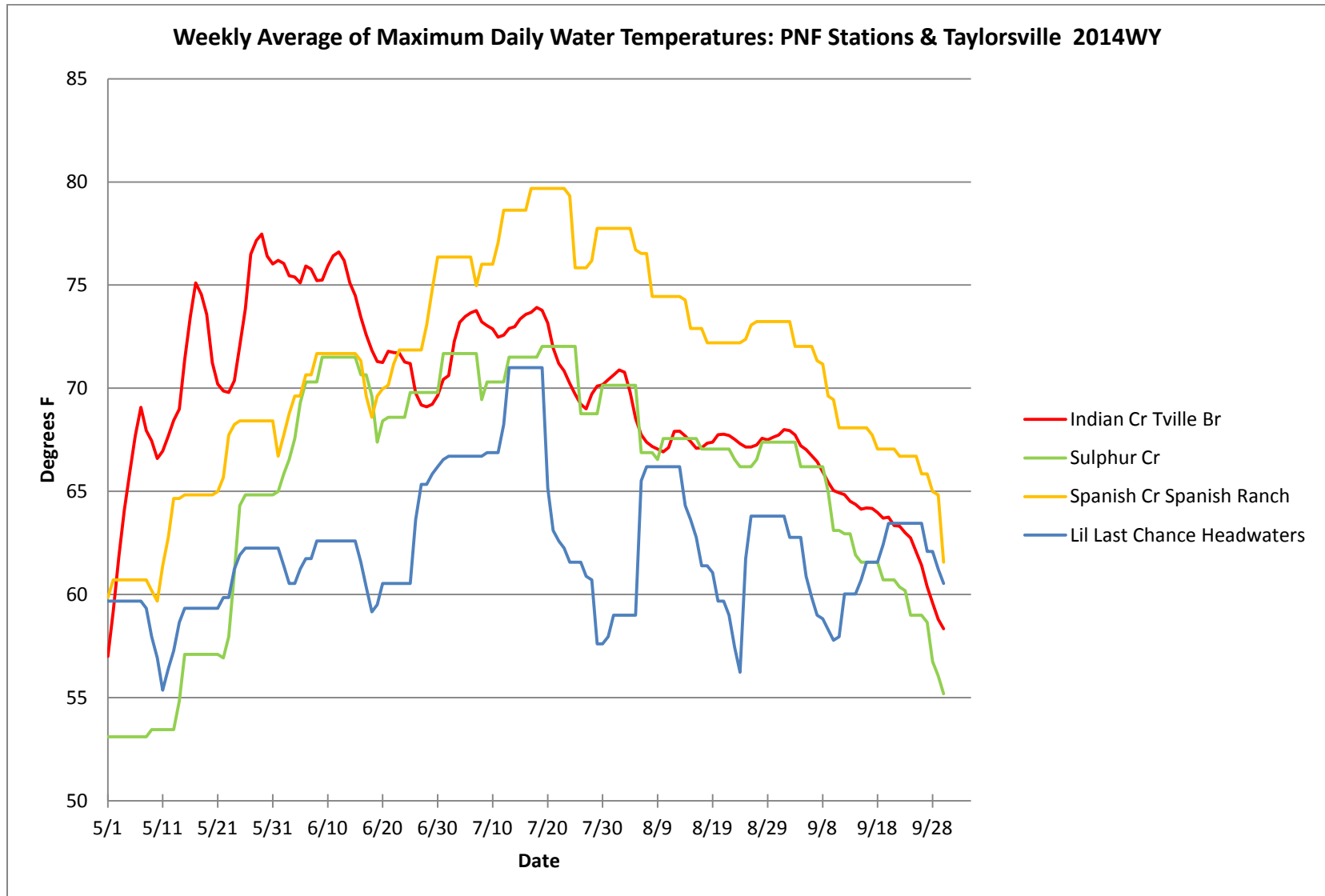


Figure 5b. Seven day average of daily maximum water temperatures at three Plumas National Forest stations and Indian Creek at Taylorsville.

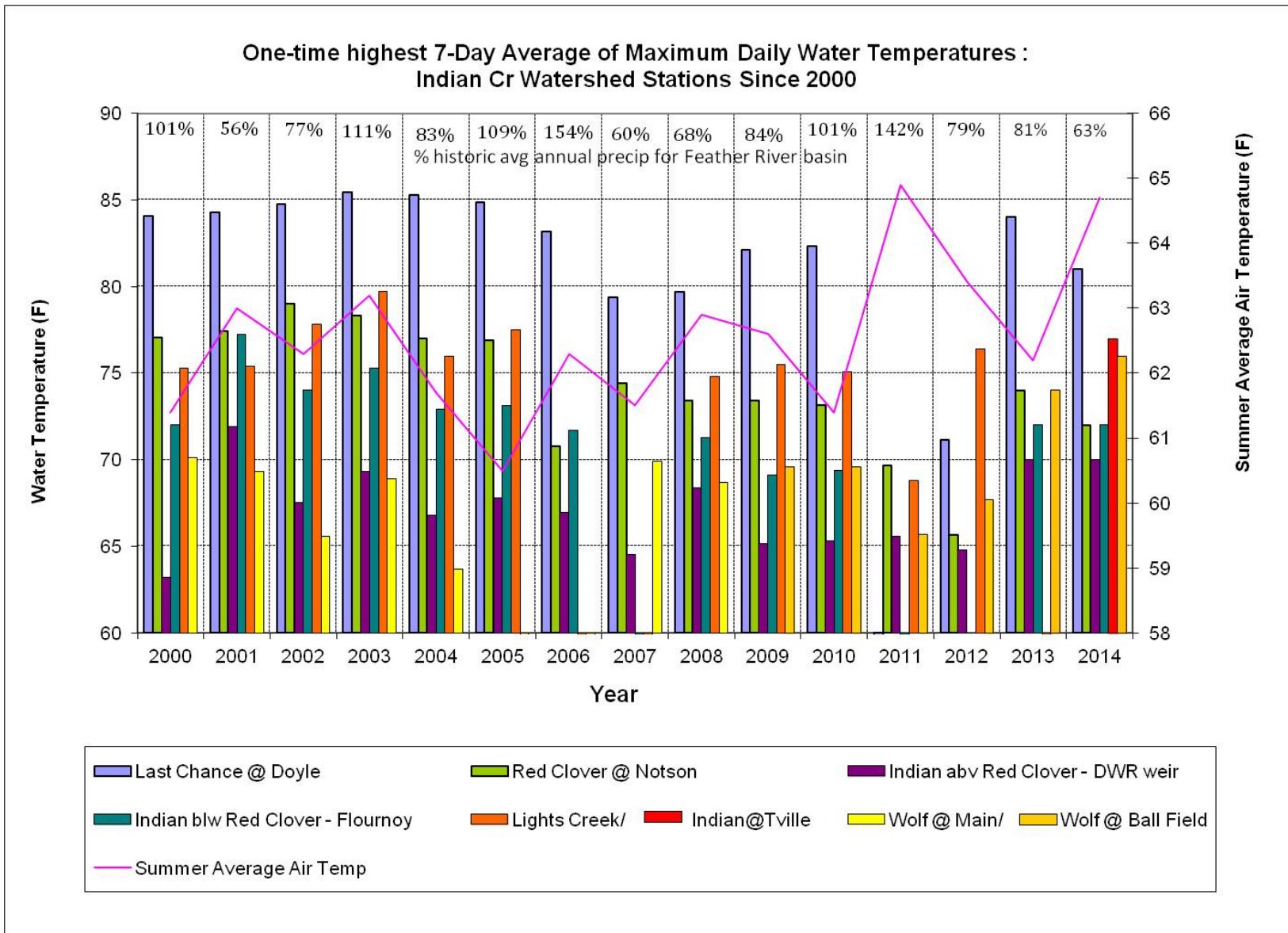


Figure 6a. One-time highest value of the Seven Day Average of Maximum Daily Water Temperatures in 2000-2014 for Indian Creek watershed stations. 2014 is the first year that Tville could record low flow. No low flow Lights Cr data since 2012.

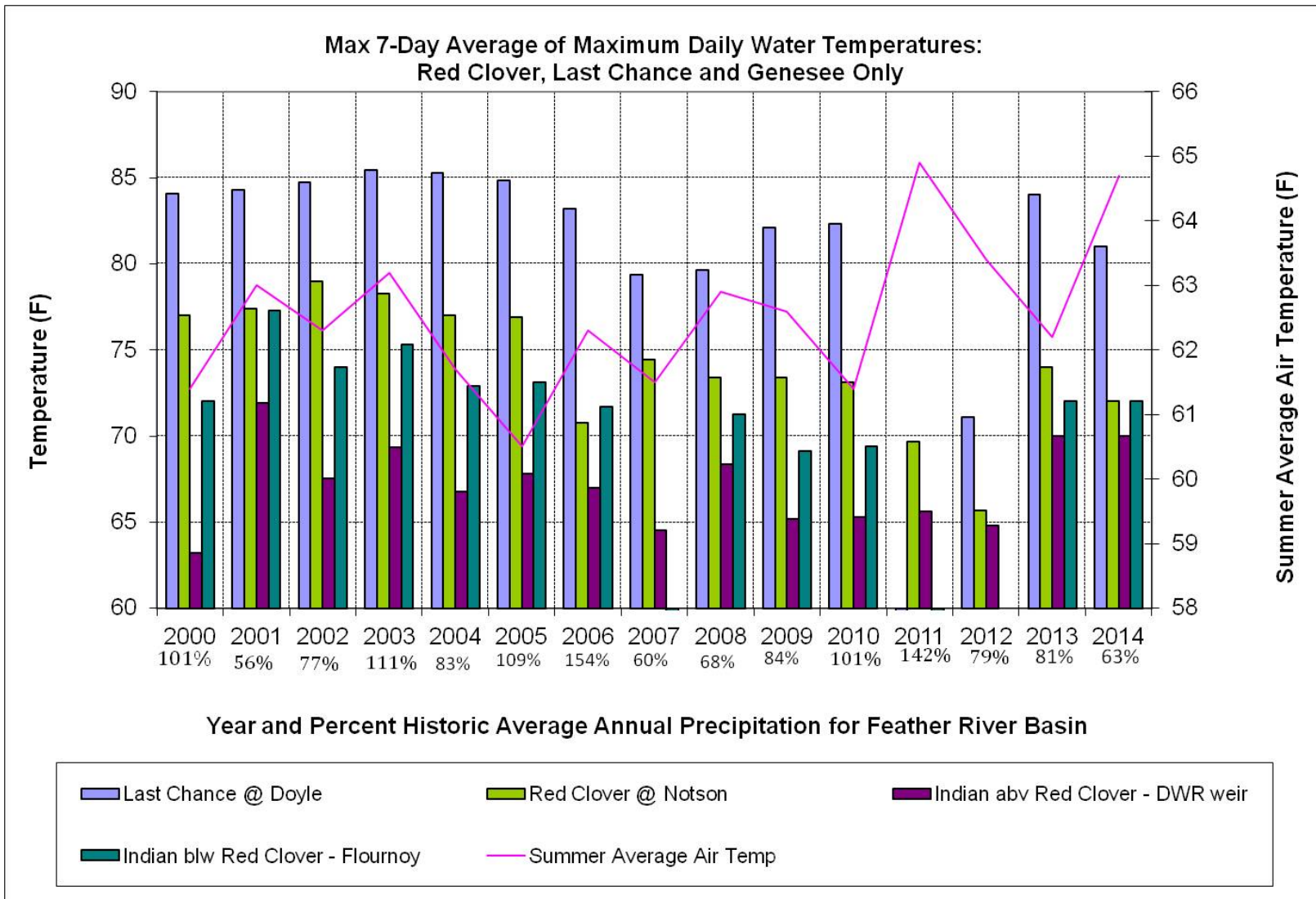
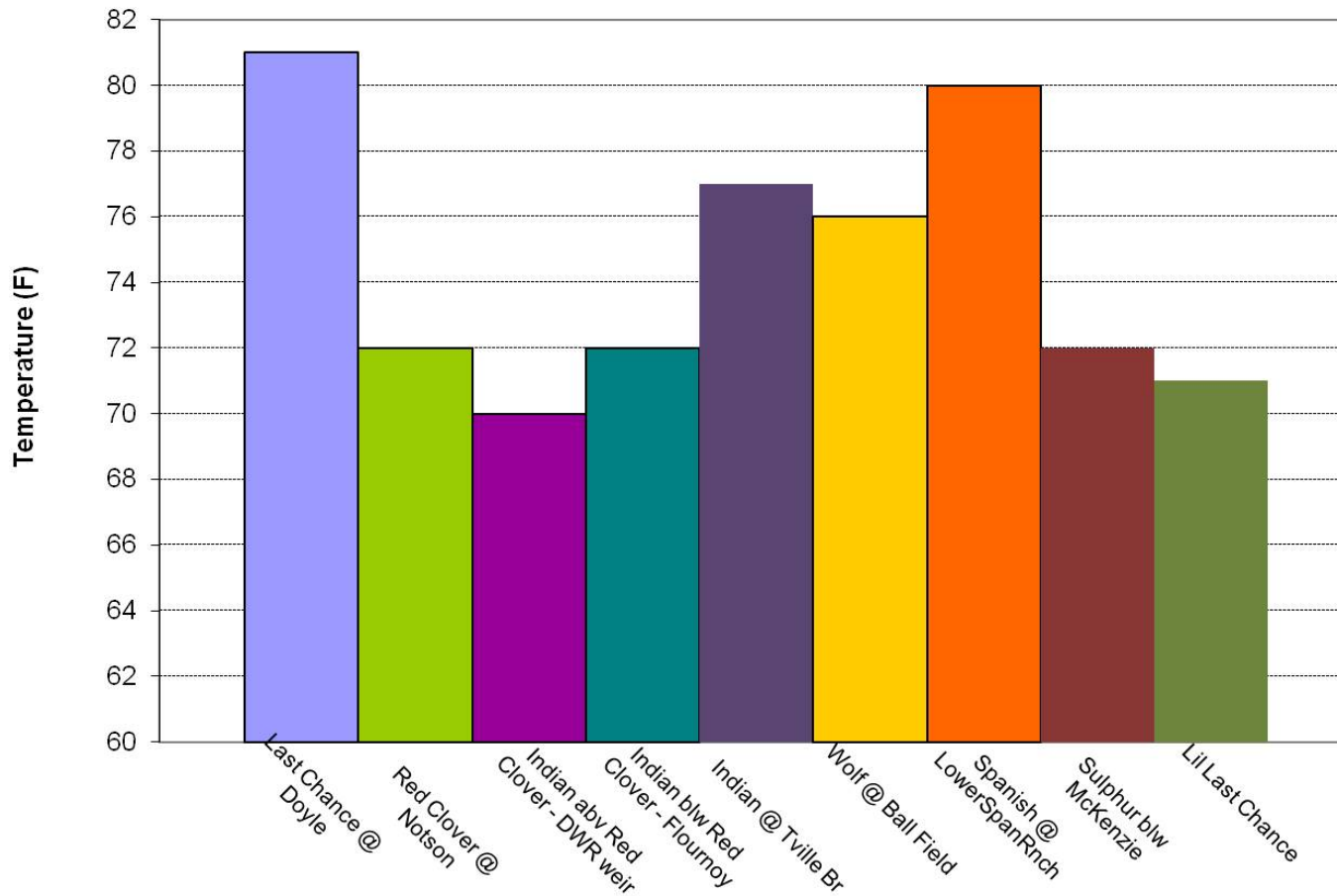


Figure 6b. One-time highest value of the Seven Day Average of Maximum Daily Water Temperatures in 2000-2014 for main tributaries and upper Indian Valley stations.

Max 7-Day Average of Maximum Daily Water Temperatures 2014WY



63% of historic average annual precipitation for the Feather River Basin in WY 2014. Summer average air temperature from June through Sept was 64.7°F.

Figure 6c. One-time highest value of the Seven Day Average of Maximum Daily Water Temperatures in 2014 for all Plumas Corp and Plumas Natl Forest stations.

Daily Maximum Water Temperature >70°F

Figures 7a and b display the number of days with at least one hour of water temperature greater than 70°F (21.1°C), which is the total maximum daily load (TMDL) criteria for temperature set by the State of California for the North Fork Feather River 303(d) temperature listing. 70°F is also biologically important for cold water fisheries; temperatures above 70 are not conducive for trout production.

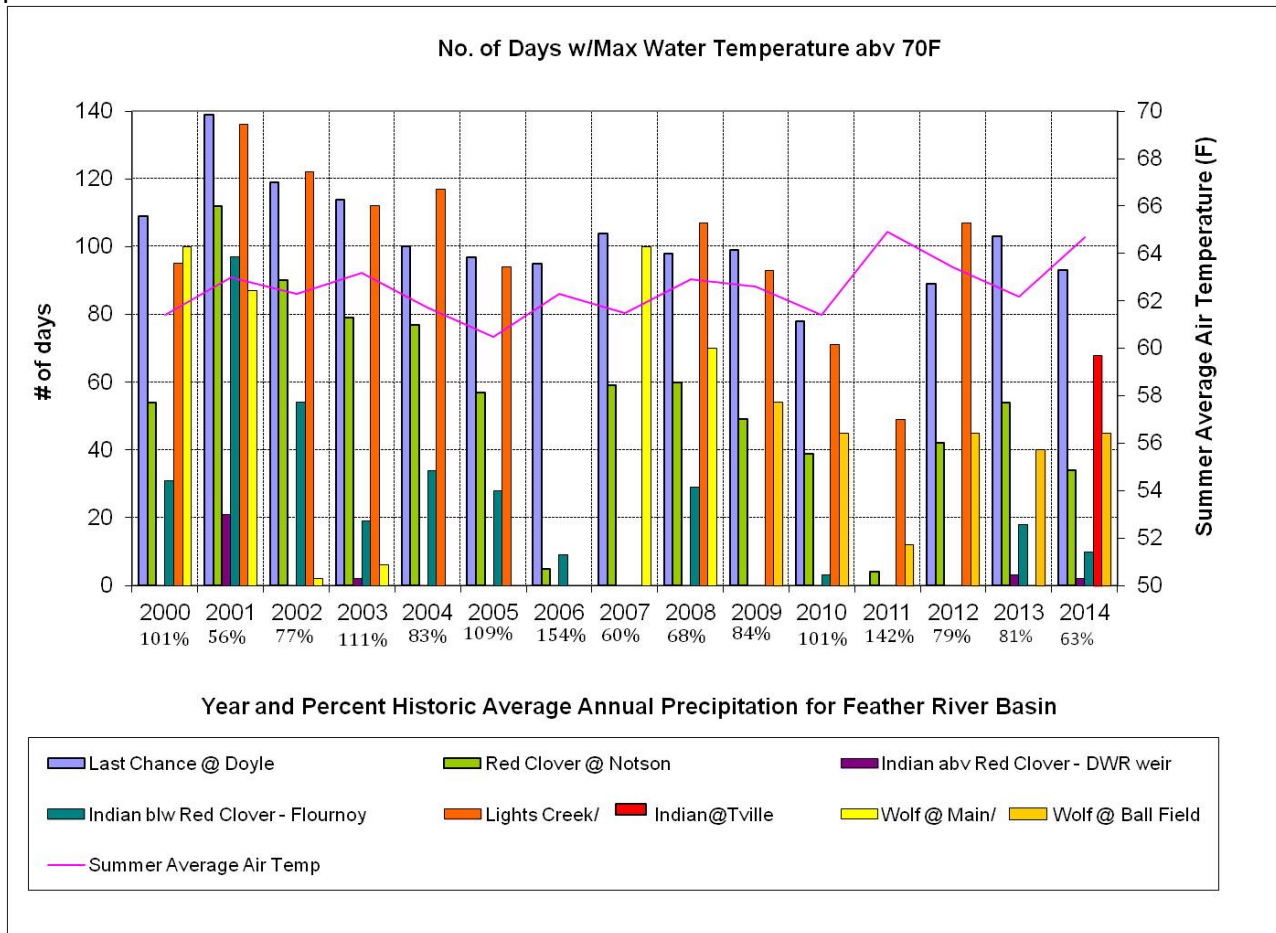


Figure 7a. Number of days with maximum water temperature above 70°F in 2000-2014 for Indian Creek watershed stations.

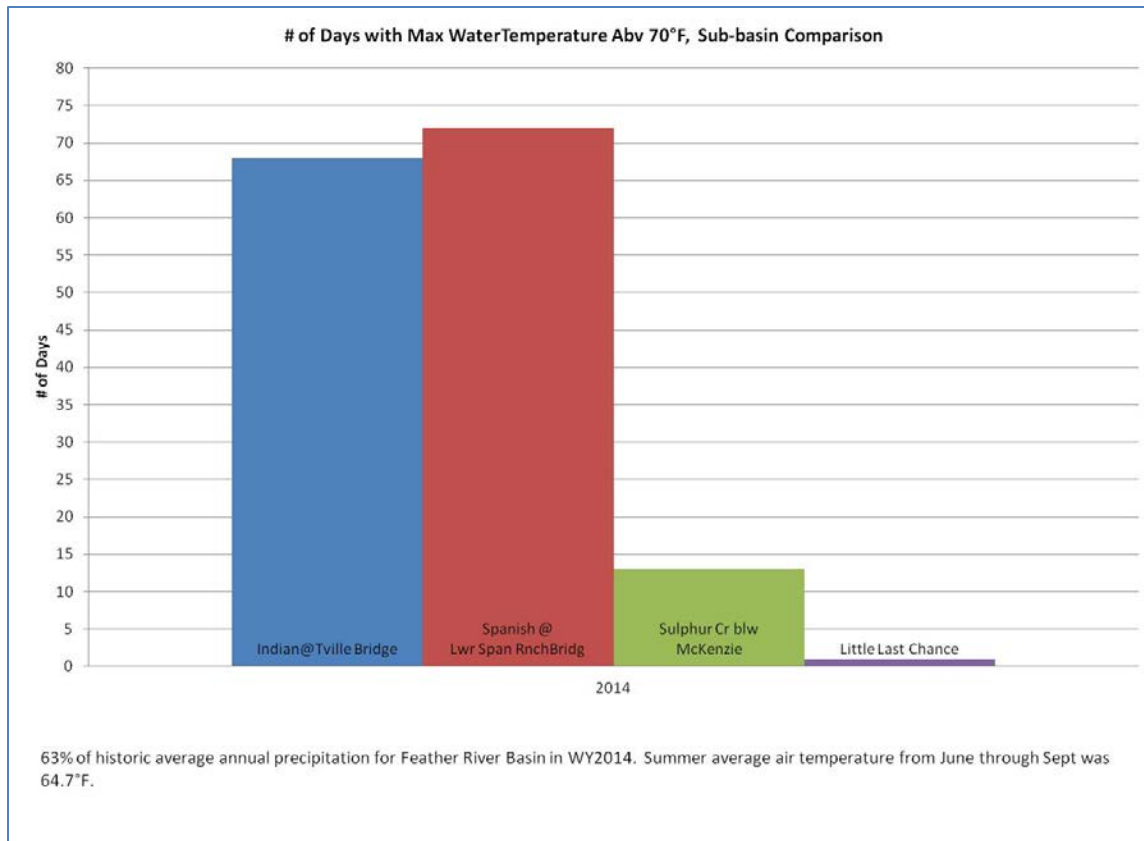


Figure 7b. Number of days with maximum water temperature above 70°F for PNF stations, and Indian Cr at Taylorsville.

As with maximum water temperatures, the number of days above 70°F decreased at Notson and Doyle from 2013 to 2014. The few number of days also decreased on Indian Creek in Genesee at Flournoy Bridge and DWR weir. Only Wolf increased. The main stems of Spanish and Indian Creeks show a substantial number of days above 70F.

Maximum summer diurnal water temperature fluctuation

Figures 8a and b display 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, insolation, and volume of water. Doyle Crossing continues to show a decline in diurnal fluctuation, without much of a trend at the other stations.

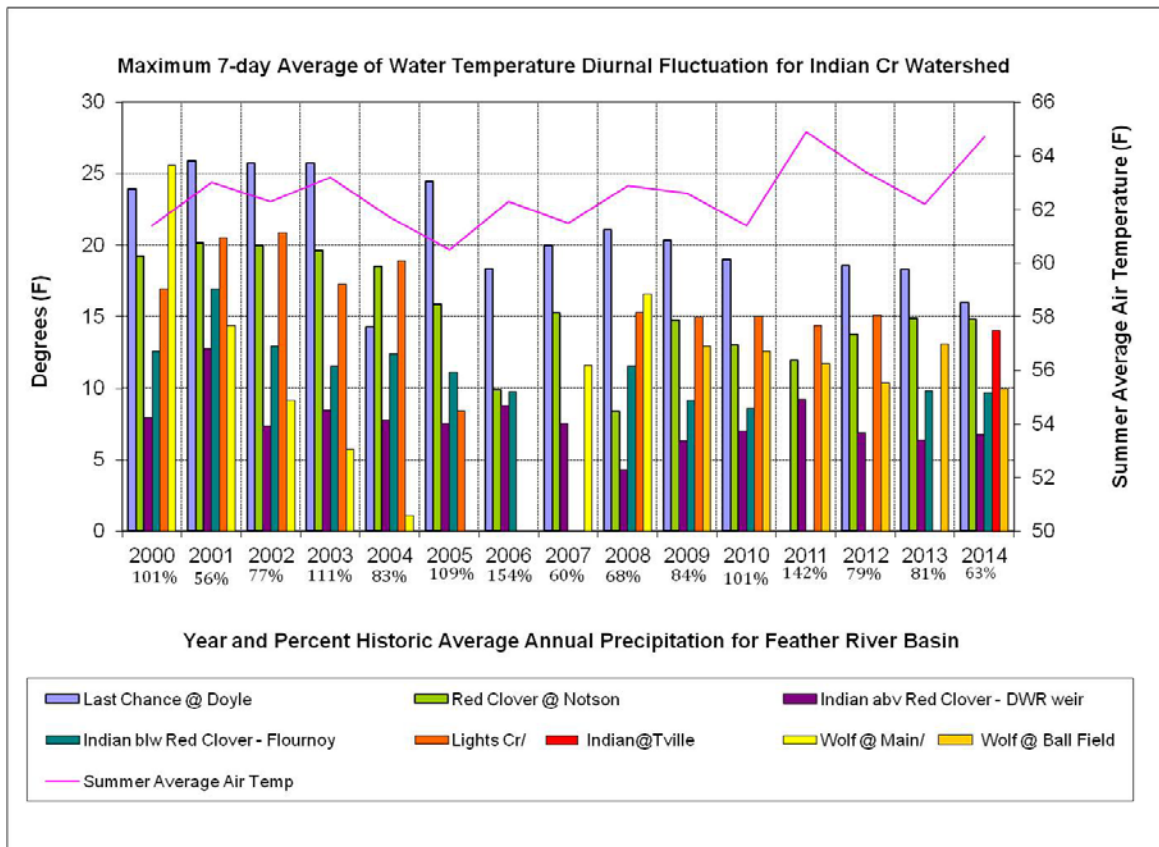


Figure 8a. One-time highest value of the 7-day average of water temperature diurnal fluctuation recorded in 2000-2014 for Indian Creek watershed stations.

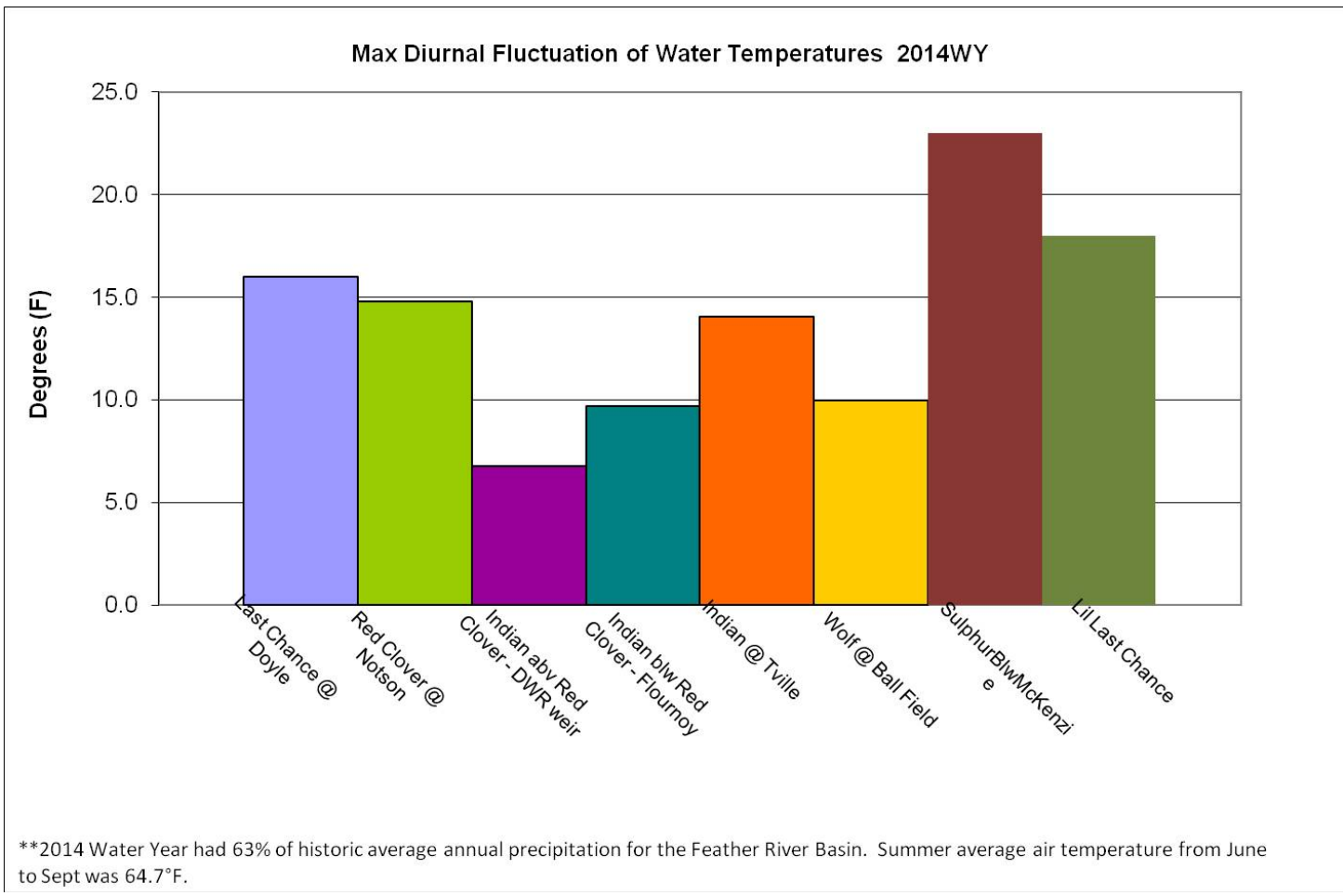


Figure 8b. One-time highest value of the 7-day average of water temperature diurnal fluctuation for all stations in 2014.

Stream Flows

A primary purpose of a nested network of stream flow 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 project focus areas. The expectation is that potential surface and sub-surface base flow and temperature changes resulting from restoration would be detected in downstream areas of the watershed, however, cause and effect is difficult to determine. The Indian Creek at DWR weir station is located below Antelope Dam. Releases from Antelope Dam are regulated year-round, thus this station does not represent natural flow conditions. Here again, Taylorsville data replaced those from the discontinued Lights Cr station.

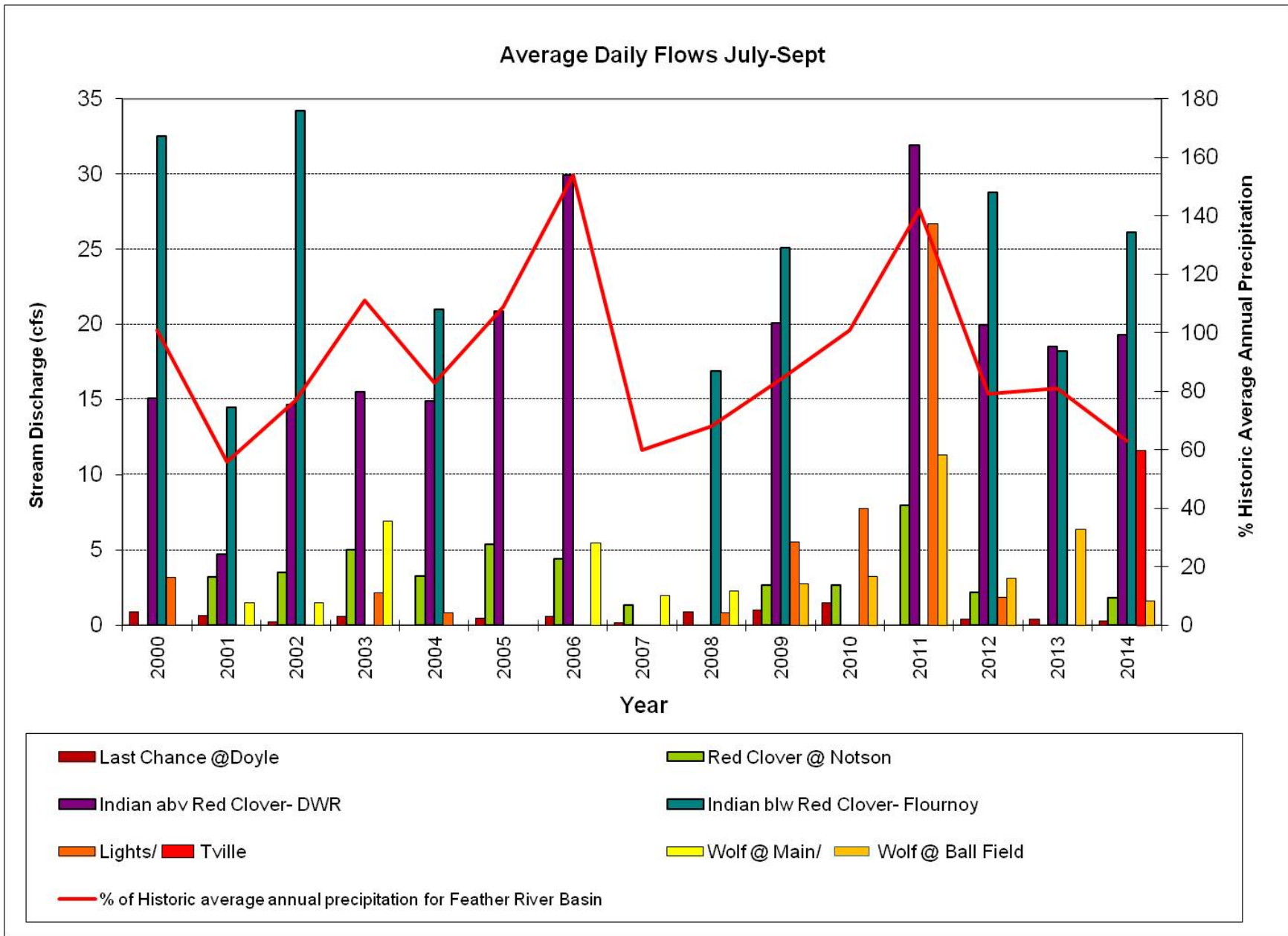
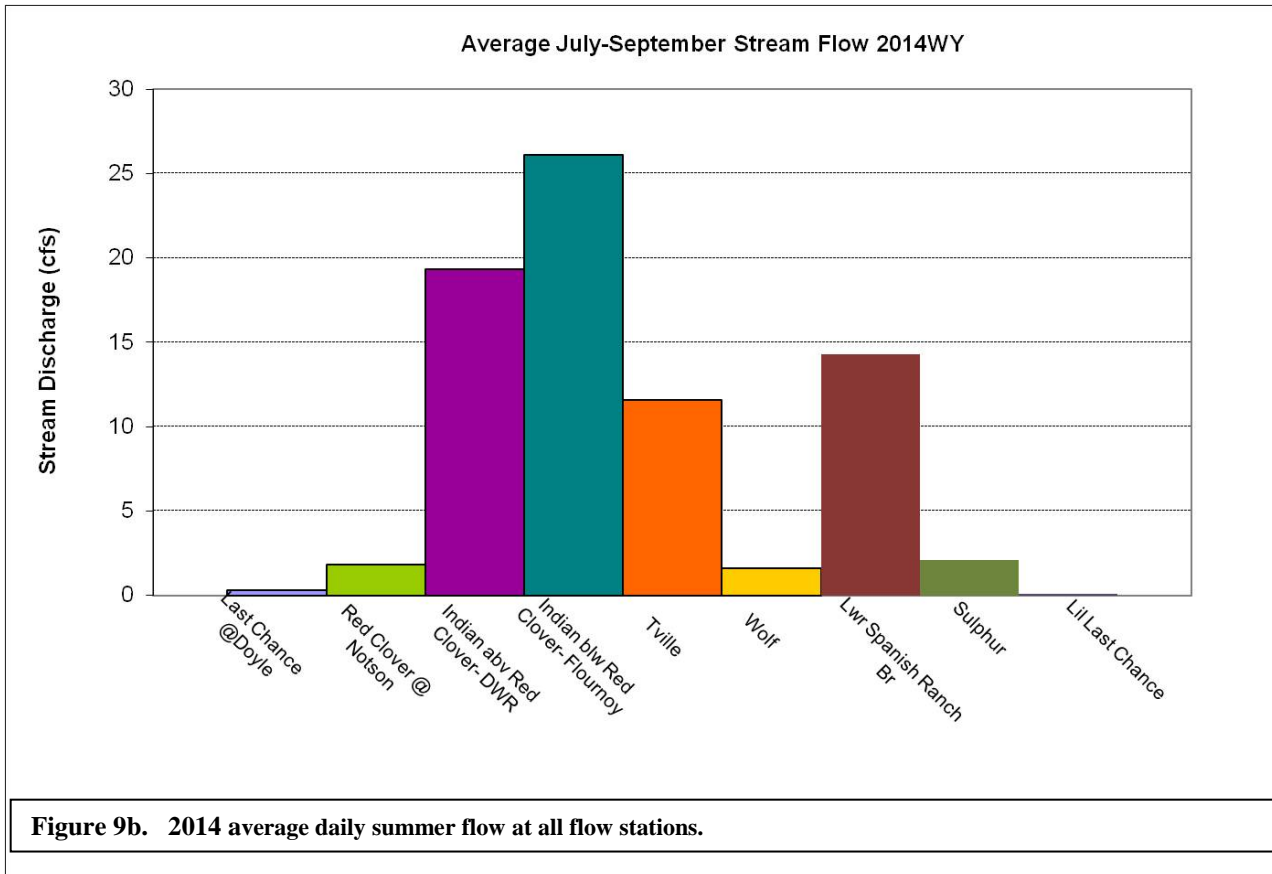


Figure 9a. Average Summer Stream Flows from 2000-2014 at Indian Creek flow stations from July 1 through September 30.



August and September Flow Volumes for Last Chance and Red Clover Creeks

Due to the increasing interest in late season water volumes emanating from the upper watershed, these monitoring reports have begun reporting a year-to-year volume of flow for August and September from the Notson and Doyle stations. The following figure displays the acre-feet of water in Last Chance Creek at Doyle Crossing from August 1 through September 30 since 2000. The volume is calculated by summing the daily average stream flows in August and September (in cfs), and multiplying by 1.9835 (A flow of 1 cfs for 24 hours equals the volume of 1.9835 acre-feet of water).

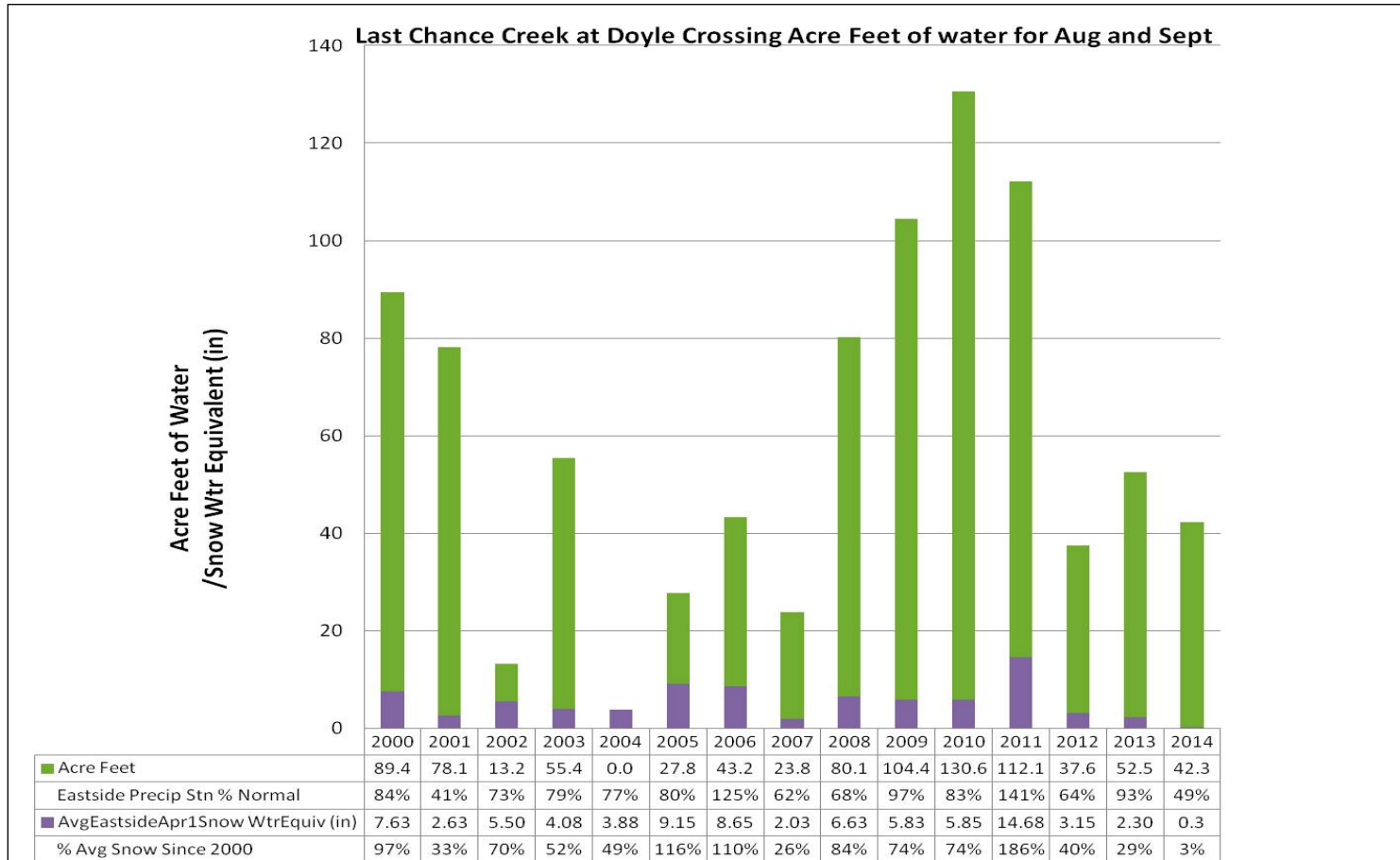


Figure 10: Late season flow volumes on Last Chance Creek at Doyle Crossing with annual precipitation and snow water equivalent data. Low flow data are unavailable for 2004 after September 5 due to equipment malfunction.

In Figure 10, snow water equivalent is also displayed, however, there appears to be no relationship between acre-feet of water in August and September and snow water equivalent. Total precipitation is likely more indicative of annual August and September flow volume fluctuations than precipitation as snow.

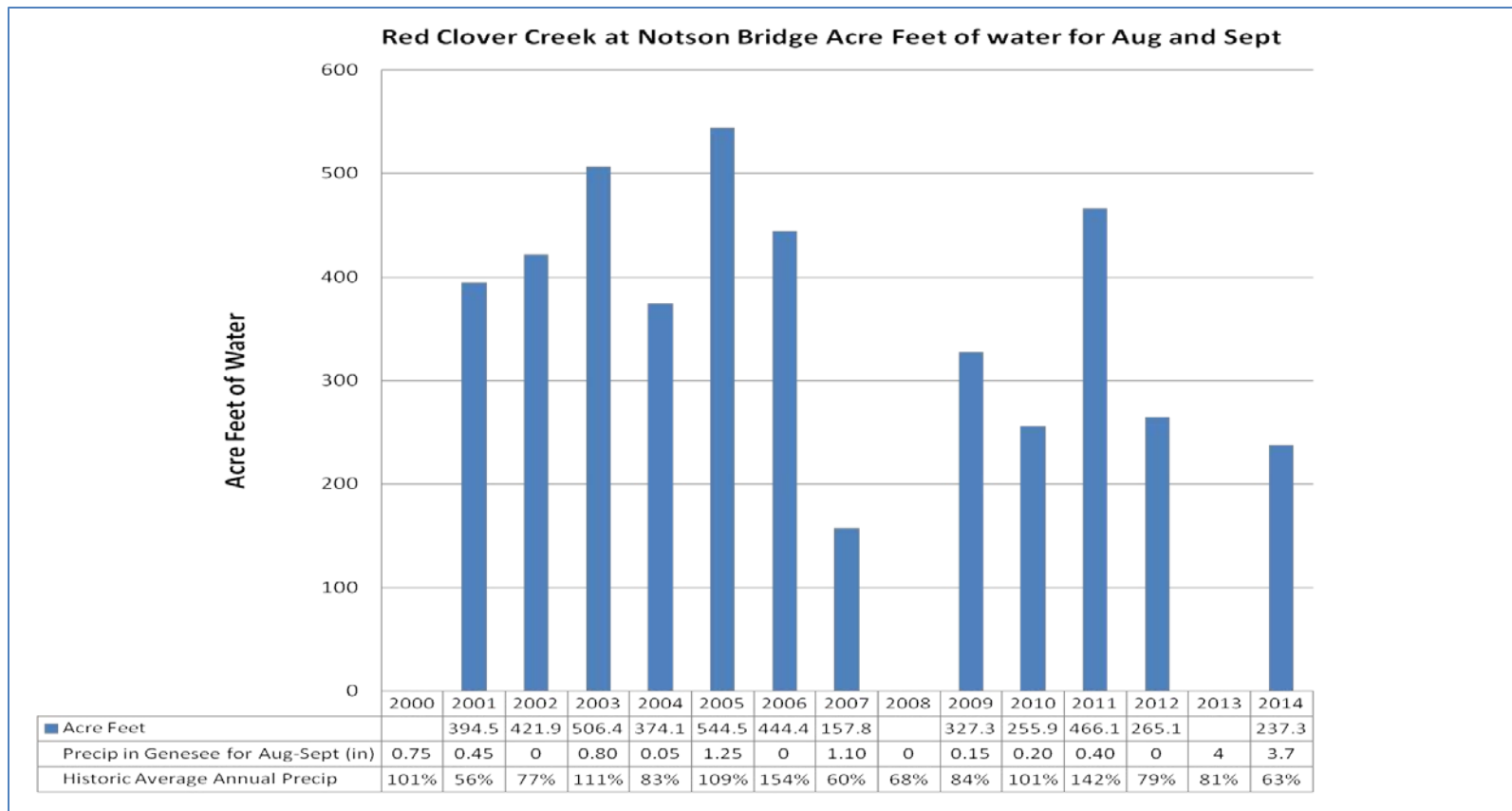


Figure 11. Late season flow volumes on Red Clover Creek at Notson Bridge. Low flow data were not available in 2008 and 2013 due to equipment malfunction.

Watershed Hydrographs

The following figures display Daily Average Stream Flow from continuous recording stations in WY2014 with precipitation data taken at the closest representative weather stations. More than one station hydrograph is displayed in some charts when appropriate. Note that Y axis scales vary between graphs to increase readability. As in 2013, there still appears to be a discrepancy between the relatively new PNF gage on Spanish Creek at the Lower Spanish Ranch Bridge, and the USGS gage near the QCSD plant. The upstream gage (Spanish Ranch Bridge) shows consistently higher flows, which does not intuitively make sense, although it is difficult to tell where/if there may be an error. The discrepancy may be due to the USGS data being provisional, and relatively few calibration measurements at the Spanish Ranch Bridge. Or the data could reflect a real diminishment in flows. It is possible that once Spanish Creek enters American Valley, it becomes a “losing” reach. The upstream Spanish Ranch gage is located at a bedrock nick point that may force all the flow to the surface, whereas the USGS gage is in an alluvial system at the edge of the valley. There are also wells up-gradient of the USGS gage.

Please Note: There were insufficient high flow calibration measurements! High flows should be considered only as estimates.

Wolf Creek at Ball Field Bridge - 2014

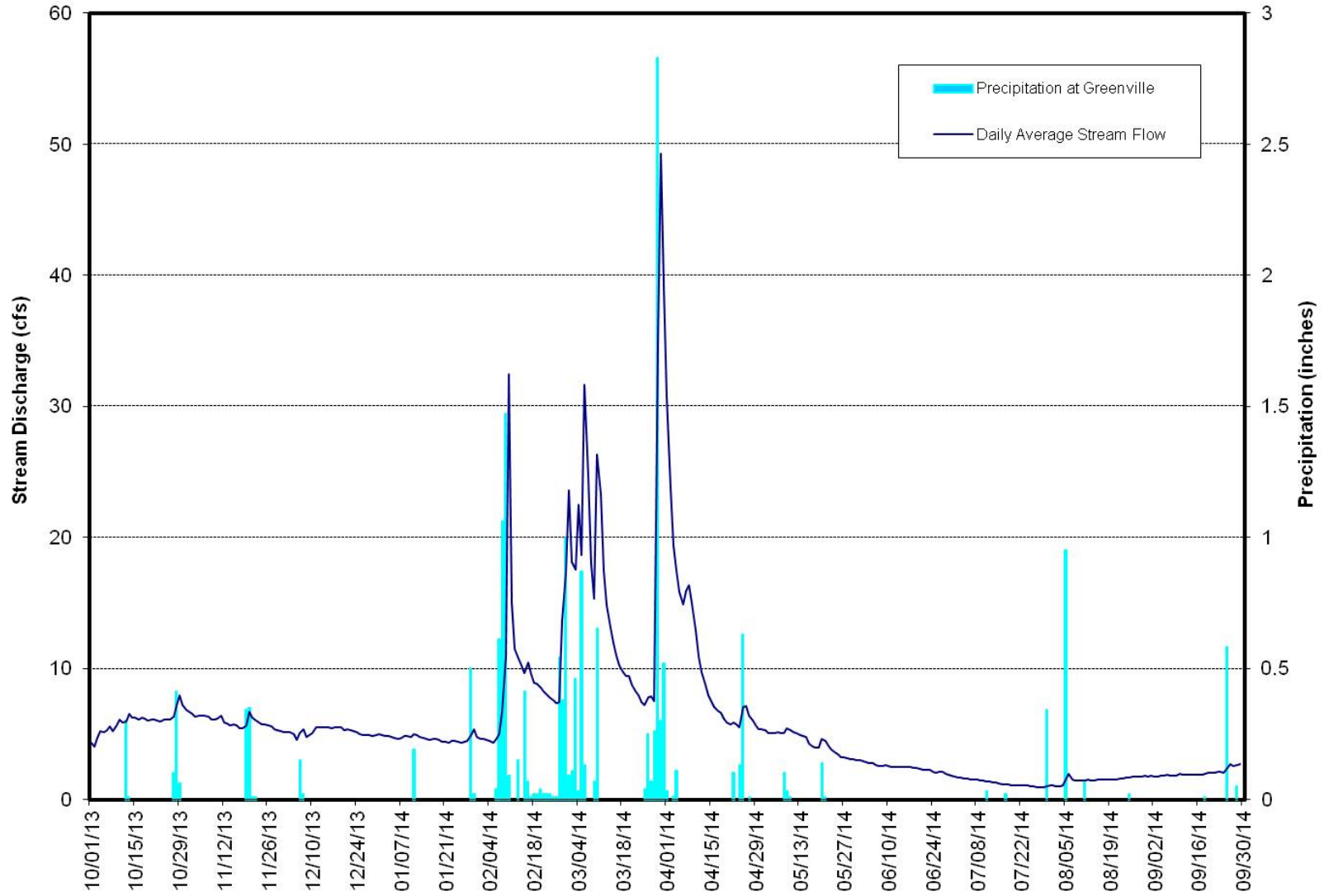


Figure 11: Wolf Creek at Ball Field Bridge Hydrograph 2014WY. High flows are only estimates.

Indian Creek at DWR Weir abv Red Clover Creek - 2014

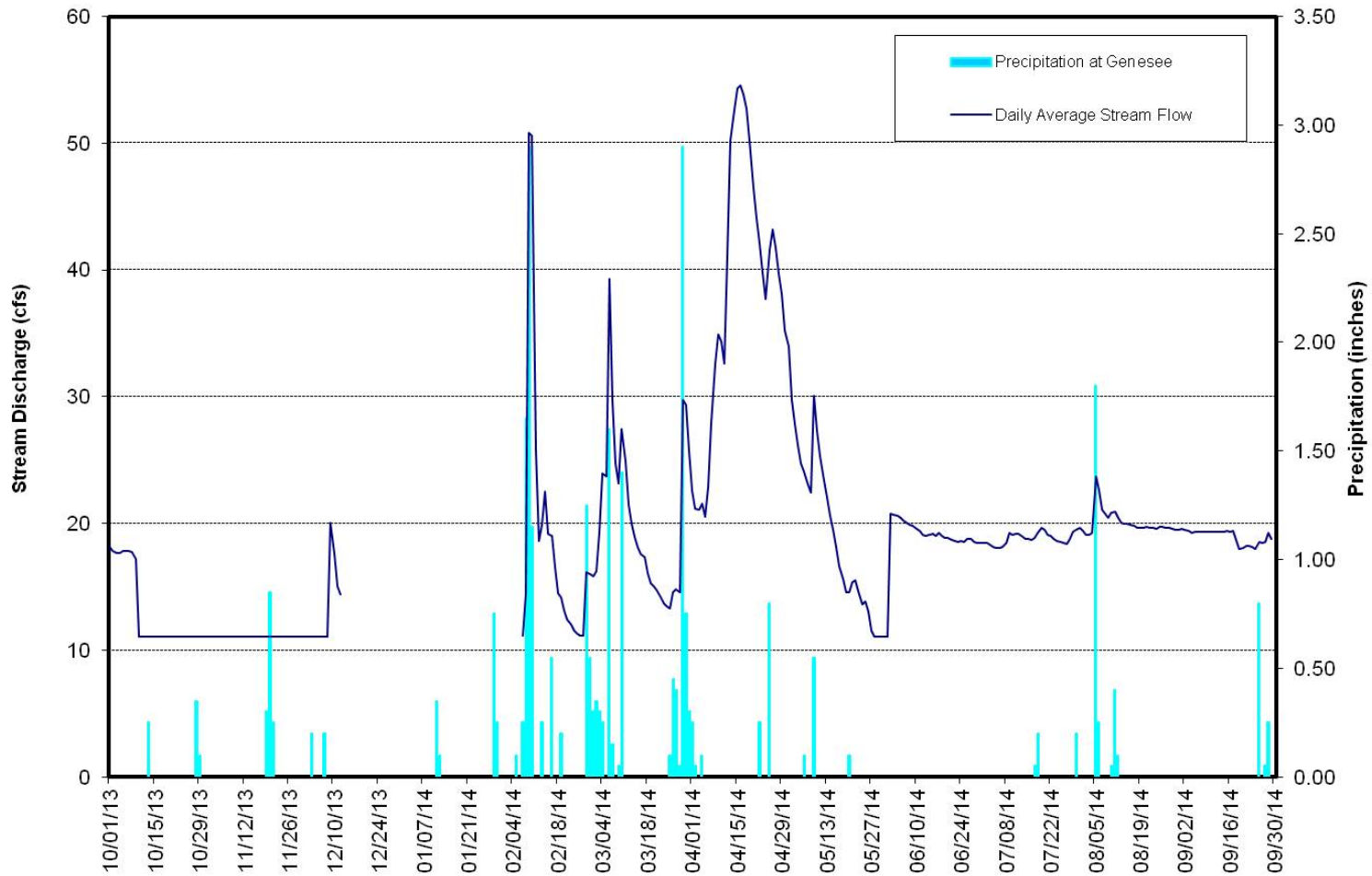


Figure 12: Indian Creek at DWR Weir Hydrograph 2014WY. Gage affected by operations of Antelope Lake. High flows should be considered estimates only. Flat line early in year represents flows below the rating.

Indian Creek at Flournoy Bridge below Red Clover Creek - 2014

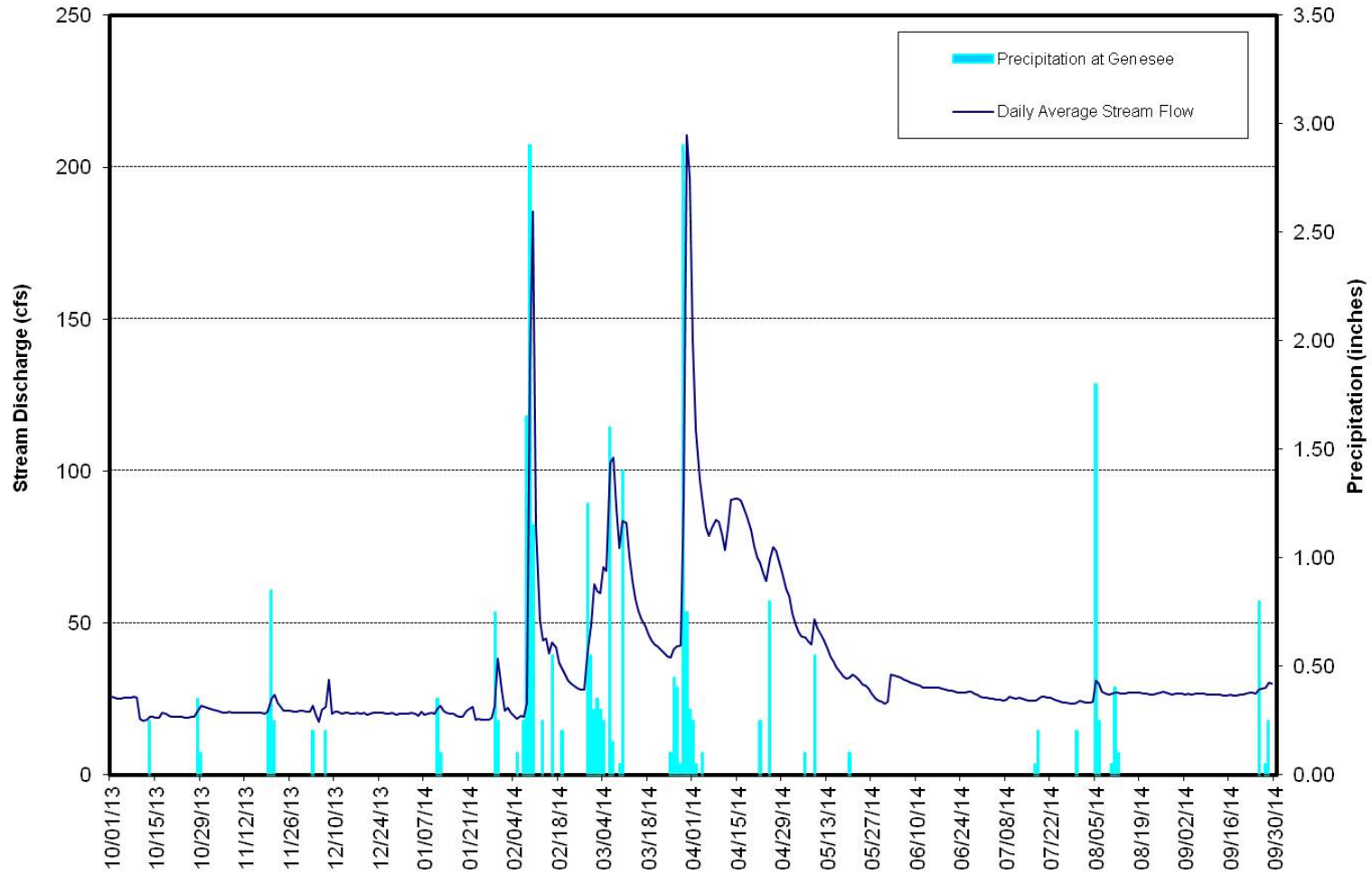


Figure 13: Indian Creek at Flournoy Bridge Hydrograph 2014WY. High flows should be considered estimates only.

Indian Creek at Taylorsville Bridge - 2014

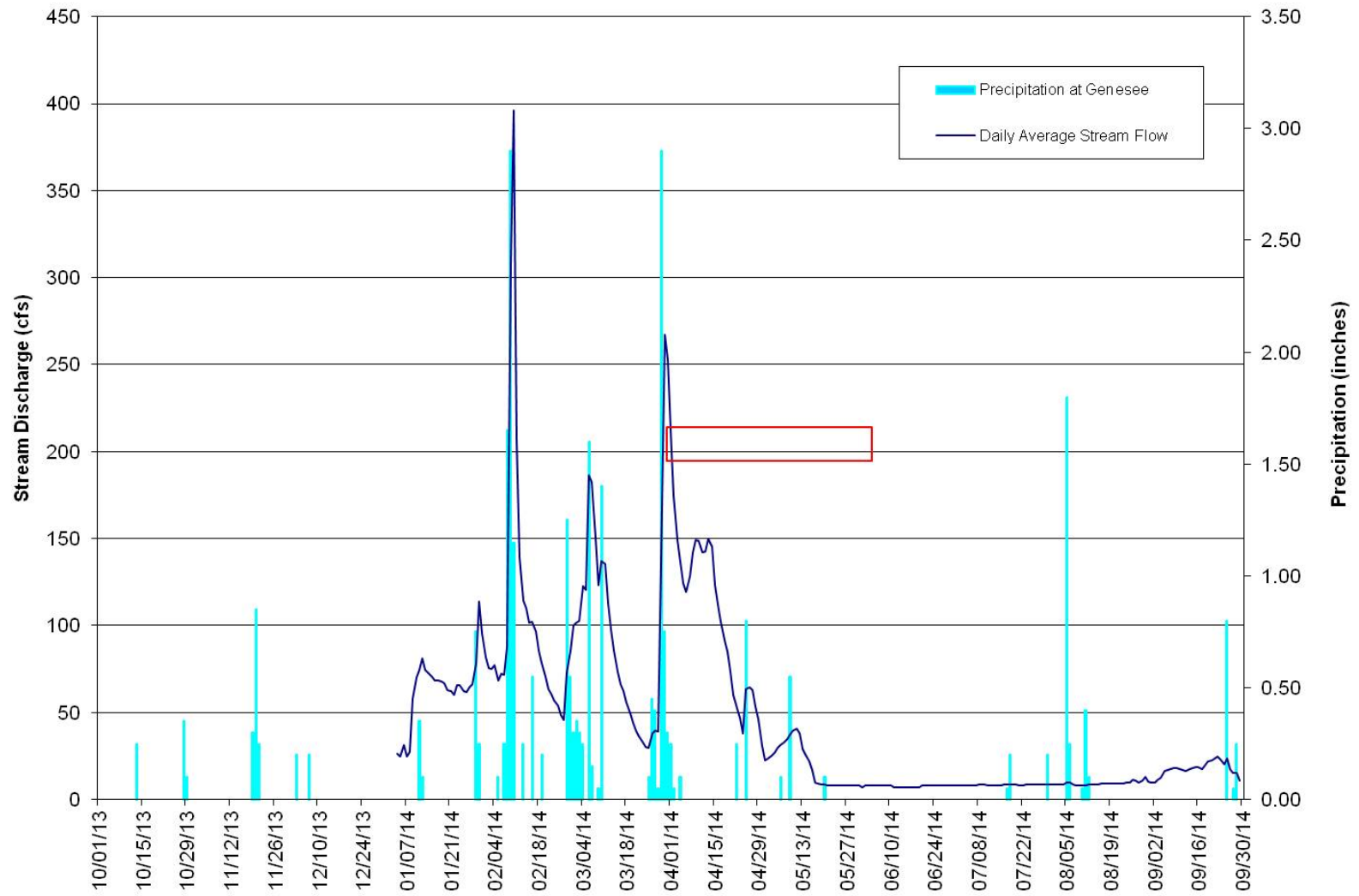


Figure 14: Indian Creek at Taylorsville Bridge Hydrograph 2014WY. High flows are estimates only.

Last Chance Creek at Doyle Crossing - 2014

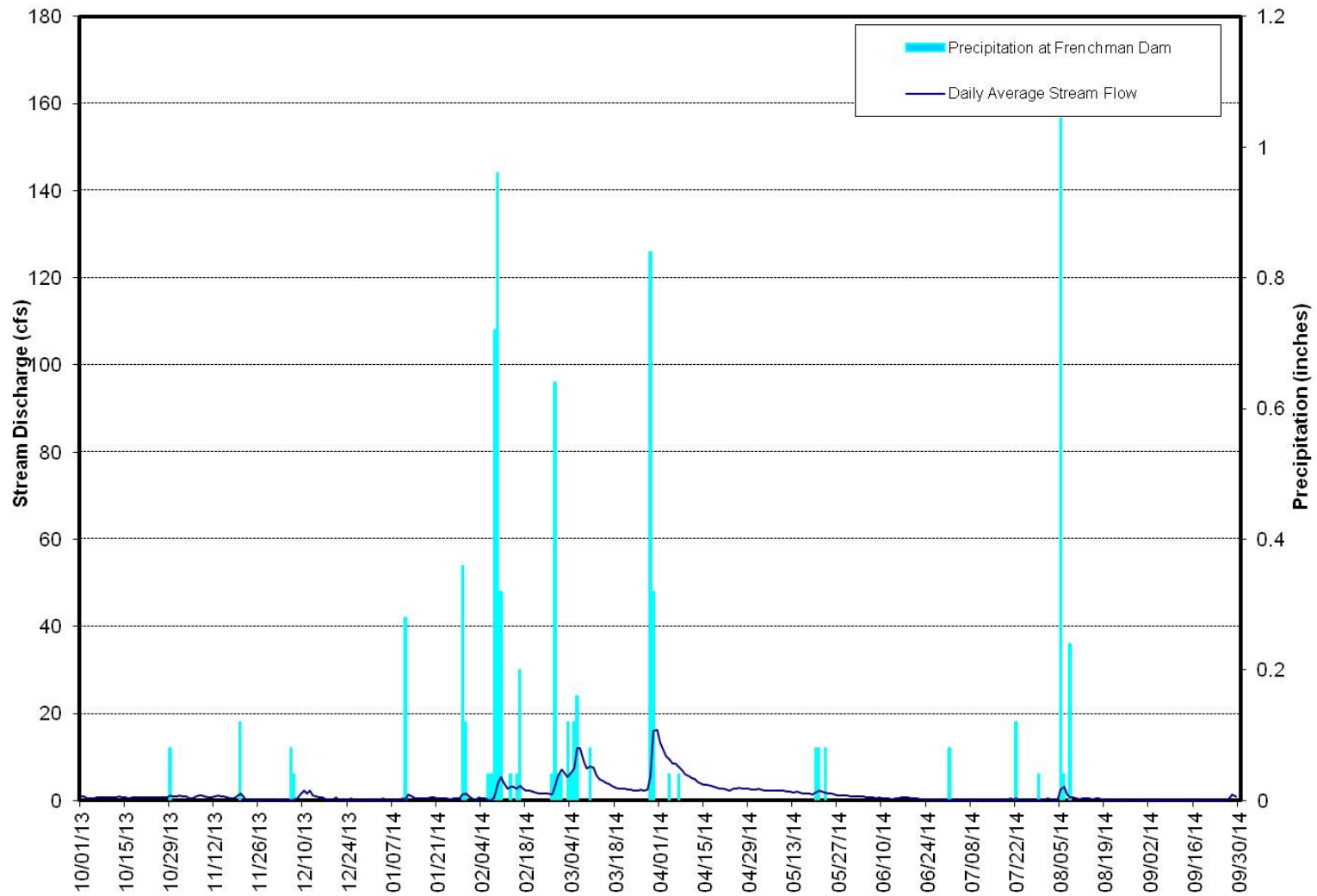


Figure 15: Last Chance Creek at Doyle Crossing Hydrograph 2014WY. High flows are estimates only.

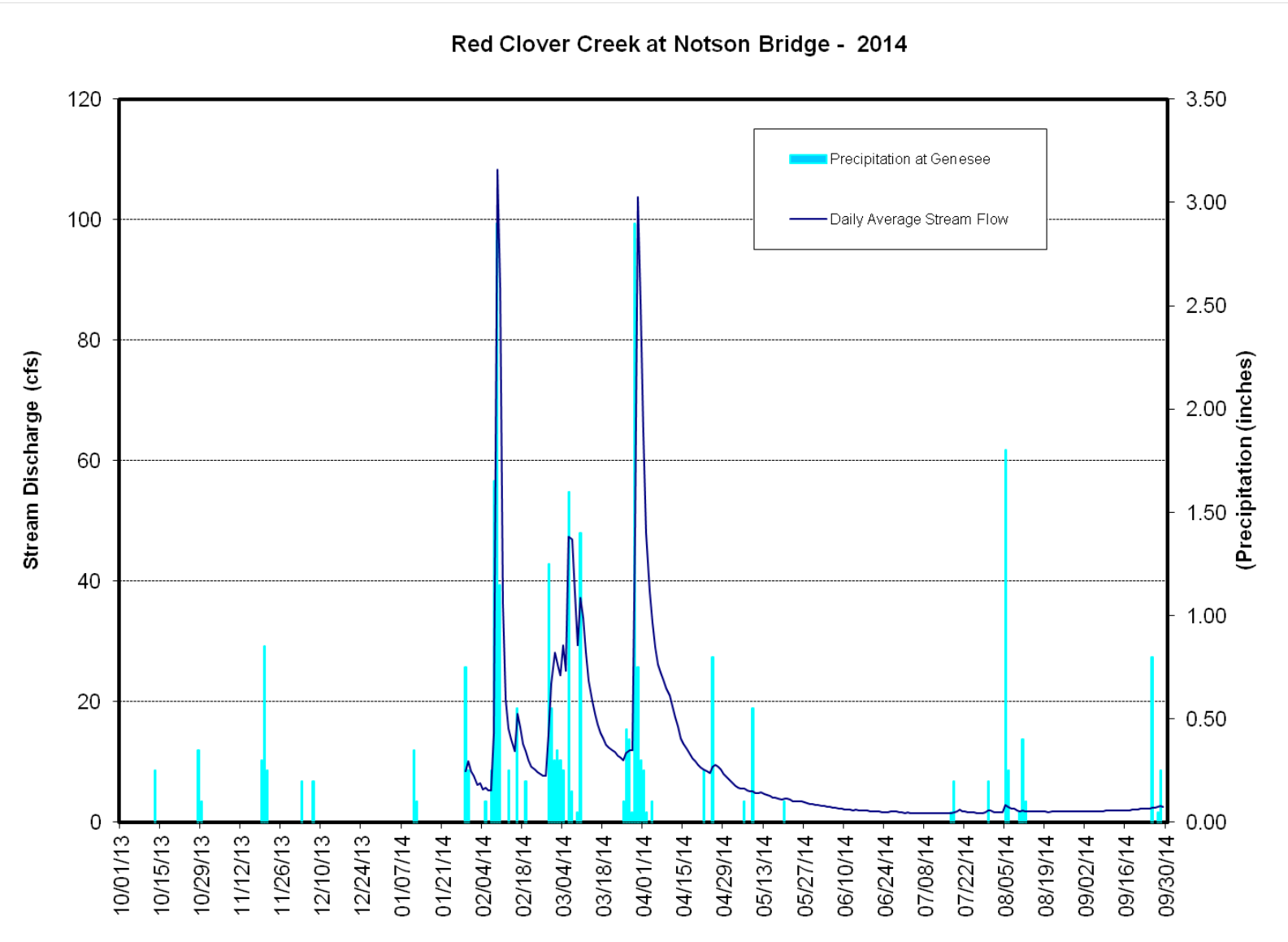


Figure 16: Red Clover Creek at Notson Bridge Hydrograph 2014WY with available data. High flows are estimates.

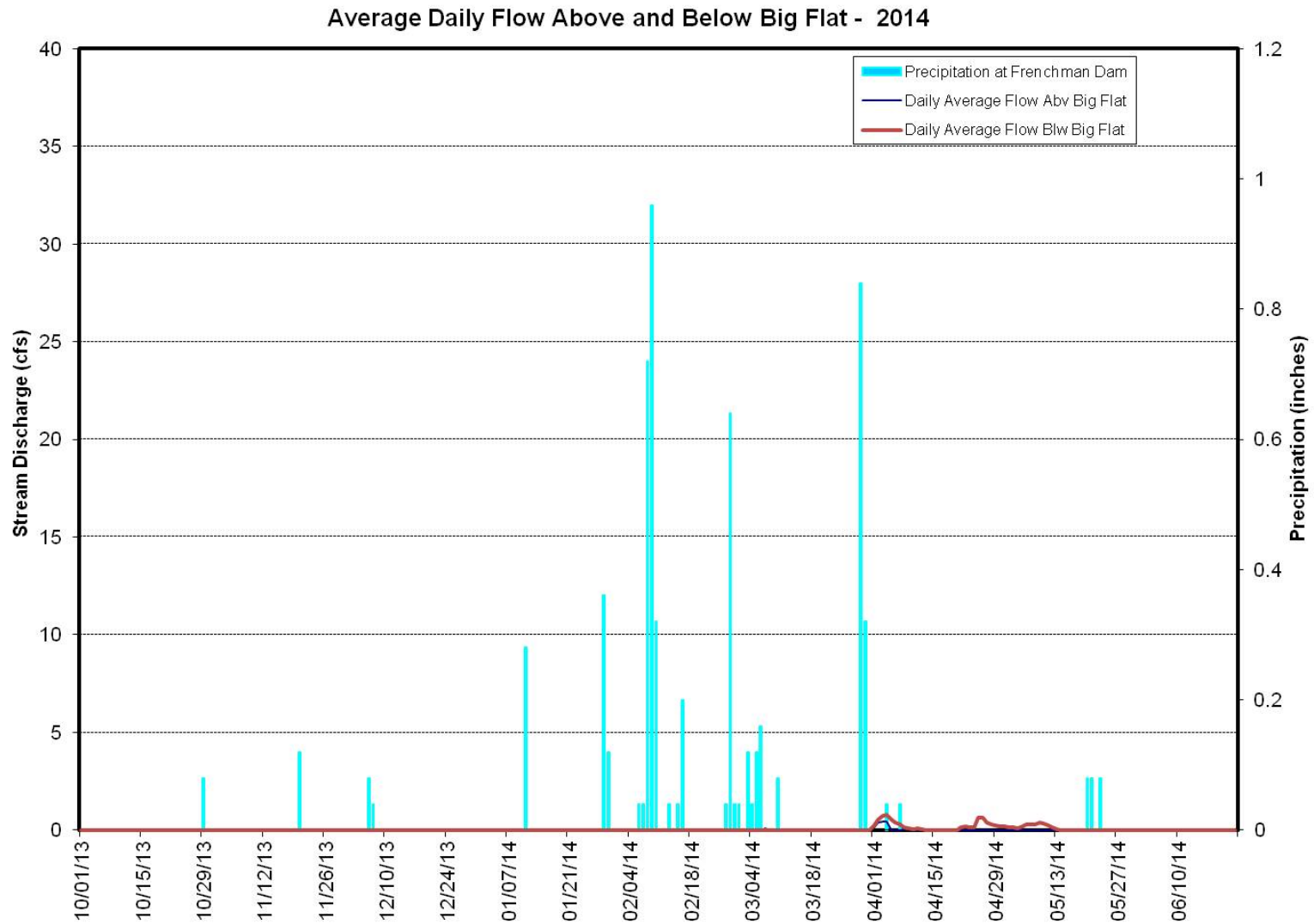


Figure 17: Cottonwood Creek above and below Big Flat project area hydrograph 2014WY. High flows are estimates.

Last Chance Creek at Million Dollar Bridge - 2013

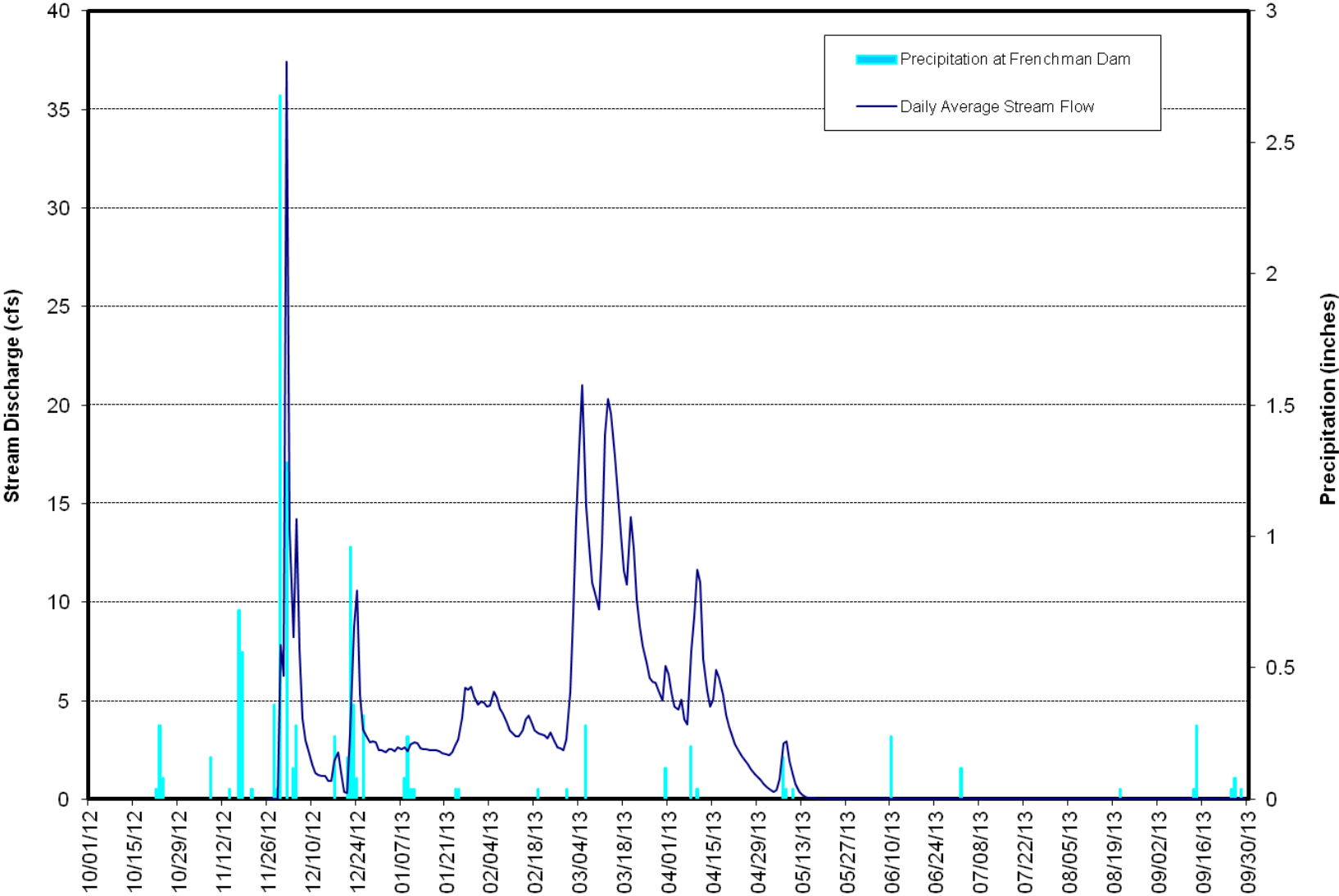


Figure 18: Last Chance Cr at Million Dollar Bridge hydrograph 2013WY. High flows are estimates.

Average Daily Flow at Two Stations on Spanish Creek - 2014

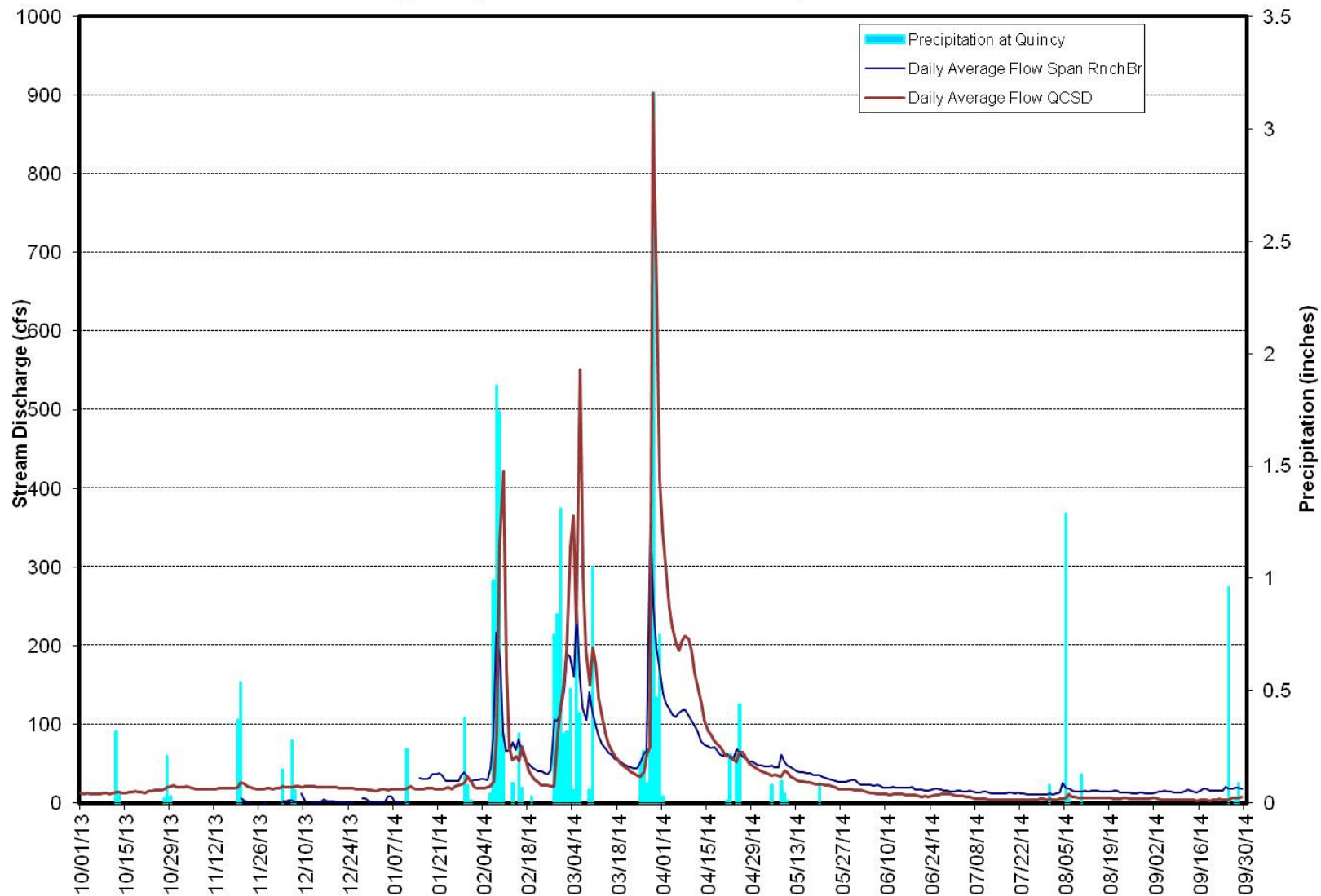


Figure 19: Comparison of Spanish Creek PNF and USGS Quincy gages 2014WY. As in 2013, these data are suspect, since this shows higher flows at the upstream station. More calibration measurements at a variety of stages are needed, particularly at the Spanish Ranch Bridge.

Sulphur Creek at McKenzie Cr - 2014

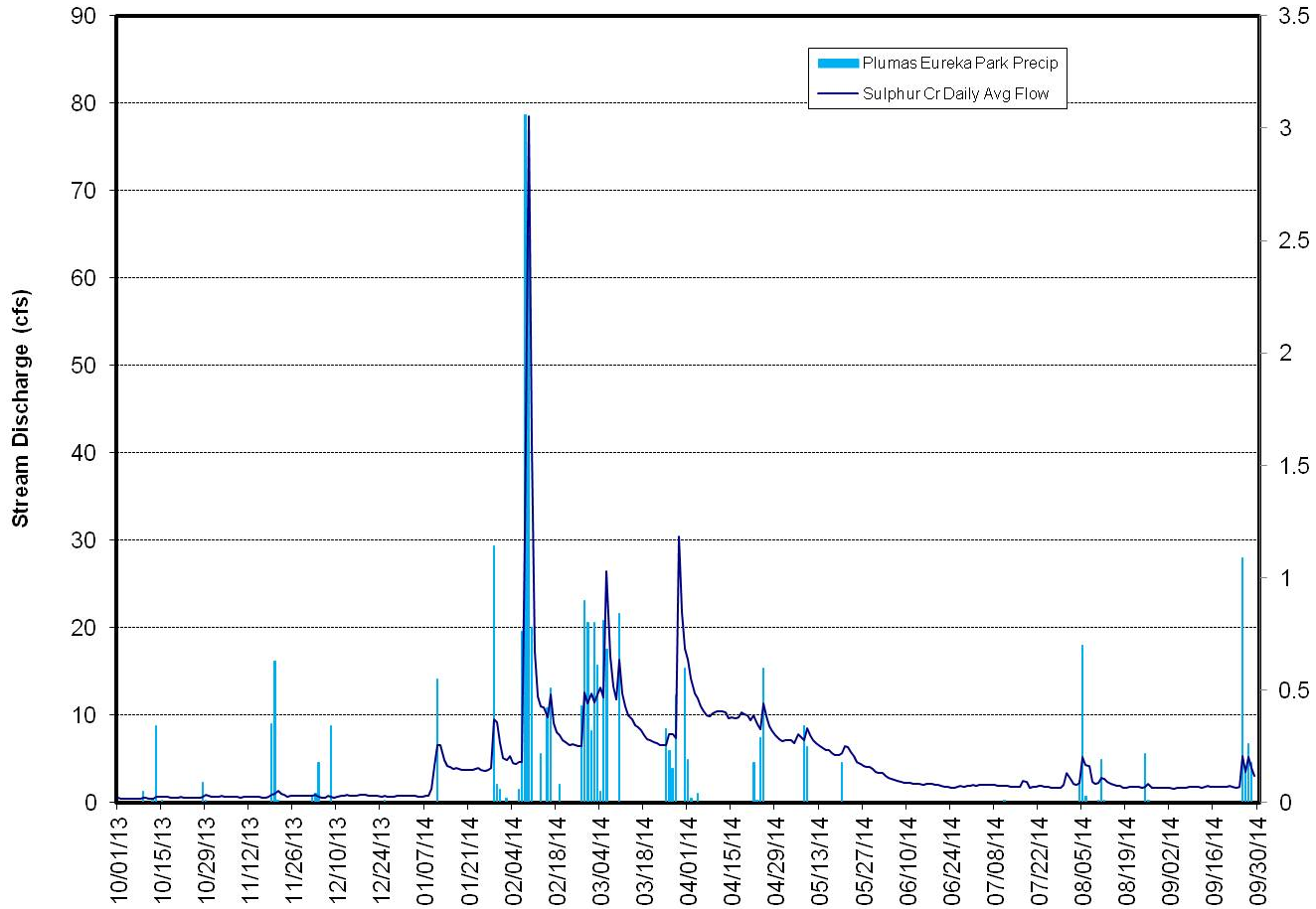


Figure 20: Sulphur Creek below McKenzie Creek Hydrograph 2014WY. The nearest weather station is at Plumas Eureka State Park. As in the other graphs, precipitation is on the right Y axis in inches. High flows not calibrated.

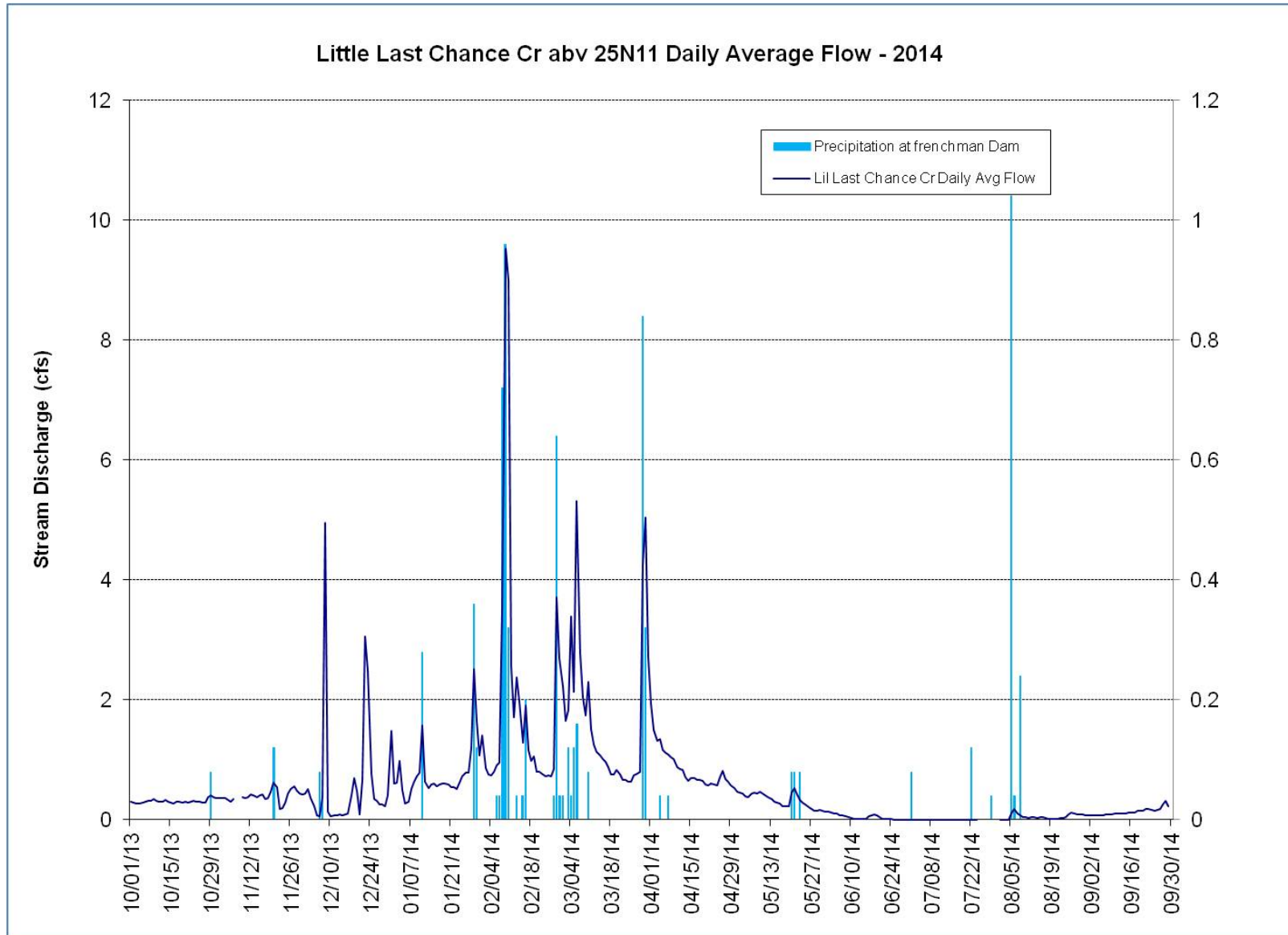


Figure 21: Little Last Chance Creek above 25N11 Hydrograph 2014WY. Precipitation is on the right Y axis in inches. High flows not calibrated.

Conclusion

The 2014 Water Year was characterized by 63% of historic annual precipitation and low snowpack, after two years of below average precipitation in 2012 and 2013. Maximum water temperature improvements on Red Clover Creek in pre- versus post-project conditions appear to be continuing through 2013, although no conclusion can be drawn on cause and effect.

Due to a paucity of measurable high flows in 2014, high flow data cannot be considered accurate. Most low flow data are well calibrated, and can be considered accurate, however, at such low flows, accuracy down to the tenth of a cubic foot per second is suspect. Accuracy is probably closer to 0.25 cfs. Additional calibration flow measurements are needed on the relatively new Forest Service stations, especially at the higher flows.

Statistical analysis has not yet shown any significant difference in flows due to restoration, except on Cottonwood Creek above and below the Big Flat project. Data from 2011 to present were not analyzed for significance in Ken Cawley's 2011 report, with no funding available to extend the analysis into recent years.