Feather River Coordinated Resource Management
Watershed Monitoring Program
Funded by Plumas Watershed Forum
2005 Report

Prepared by Plumas Corporation
Quincy, CA
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EXECUTIVE SUMMARY

The most salient findings in this report are:

- Last Chance and Lights Creek continue to be the most temperature-impaired channels.
- Wolf Cr is showing improvement in temperature, possibly due to increased shade from riparian vegetation since restoration projects in early 1990's, and increased depths from recent beaver activity, or sensor error.
- Red Clover Creek tends to warm up Indian Creek.
- Expected improvements in base flow may be restricted by evapotranspiration.
- Last Chance may be showing some flood attenuation resulting from restoration, however, no base flow improvement. This is a very cautious and tentative conclusion....
- The rate of decline of the falling limb may be the most responsive peak flow parameter to changes due to restoration.

***Please note: Excel-generated Tables and Figures are all located at the end of the report.** The reader is invited to skip the text, and develop your own interpretation of the data. Monitoring the effectiveness of project work on a watershed scale is fraught with difficulties, not the least of which is the ability to assign cause and affect relationships to perceived differences in data. It should also be noted that flow data has a 10-15% margin of error. All conclusions in this report are made with these caveats in mind.

RECOMMENDATIONS FOR FUTURE MONITORING & ANALYSIS

- Even in baseline-funded years (like 2005), include some additional biologically significant parameters in the monitoring.
- Flow monitoring is good, but very difficult to attribute cause and effect. Perhaps look to modeling for those answers, and use this monitoring to validate the modeling.
- Add in observational and project situation anecdotes to give further context to the numbers.
- When appropriate and possible, include project monitoring in this watershed monitoring report.
- Include grab sample turbidity sampling during flow sampling, especially during events. Don't try to assign a suspended sediment quantity to grab samples.
- Be sure that error margins (10-15%) are considered in making comparisons in flow.
- Because of the high flows in winter/spring 2006, complete Monitoring Reach surveys in 2006 or as soon as possible. If no funding, prioritize one or two to complete in 2006.
- Add air temperatures to Table 1 to better characterize the climatic situation in each year.
- Comparisons of event flood attenuation are further complicated between years or between sites by the presence, or lack, of snow. Snow precip (vs. rain) can only be derived from weather stations by looking at temperature. Snow on the ground can only be derived by observation.
- Include expected versus observed data in the discussion of each question.
- Try analyzing summer diurnal flow fluctuations as a surrogate for evapotranspiration, or use continuously recorded groundwater elevations in wells (as in the Last Chance Stanford study).
- Monitoring in 2004 & 2005, reported herein, was guided by recommendations in the 2003 SWAMP final report. This report concurs with those recommendations, as well as those listed above.

INTRODUCTION

Program Background

This report tiers off two previous FR-CRM Watershed Monitoring Reports. It includes on-going monitoring data from 2004 & 2005. Background information such as an overview of the watershed, monitoring program objectives, and protocols can be found in those reports. The program began with a federal Clean Water Act grant (Aug 1998 to Dec 2000). The California Surface Water Ambient Monitoring Program (SWAMP) funded the program from Oct 2000 to Dec 2003. Both reports can be found on the FR-CRM website at feather-river-crm.org. Work funded by the Forum was guided by recommendations in those reports. The primary goal of this program was to continue operation of the ten continuous recording stations. Additionally, some project sites were included that have watershed-level significance. Physical and biological surveys of the 20 Monitoring Reaches were not included in this effort. Those sites will likely be re-surveyed in the next one to two years since the New Year's Eve flood of 2005 may have caused changes that would be instructive to observe.

Overall Monitoring Program Description

There are four main Feather River subwatersheds covered under this monitoring program: Indian and Spanish Creeks (which together make the East Branch North Fork Feather River (EBNFFR), the North Fork Feather, and the Middle Fork Feather. Most of the monitoring effort is concentrated in the Indian Creek watershed because of its highly degraded upper watershed condition, and high potential for benefit from restoration with many square miles of alluvial valleys. Site location follows a nested approach.

Only operation and maintenance of the Continuous Recording Stations (CRS) sites are funded by this grant (see Figure 1). Monitoring Reaches (MR) are included in the following schema and in Figure 2 to give the reader an idea of the breadth of the overall watershed monitoring program. Monitoring Reaches have been surveyed three times for geomorphic, habitat, chemical, and biological characteristics. Long term monitoring of these sites is expected to give watershed managers a better understanding of processes and long term trends in these subwatersheds. The types of data collected at Monitoring Reach sites can be found in the SWAMP final report, with details on protocols in Appendix A.

The monitoring sites are nested within sub-watersheds as follows: (“acw” means “above confluence with”)

North Fork Feather River watershed

NFFR @ acw East Branch	(MR)
Butt Cr	(MR)
Goodrich Cr	(MR) (discontinued)
NFFR @ Domingo Springs	(MR)
East Branch mouth	(MR)
Spanish mouth	(MR)
Spanish Cr acw Greenhorn	(MR)
Greenhorn Cr mouth	(MR)
Spanish @ Gansner	(CRS)
Rock Cr mouth	(MR)
Indian Cr @ Indian Falls	
Wolf Cr @ Park	(MR)
Wolf Cr @ Main St Bridge	(CRS)
Lights Cr	(MR & CRS)
Indian @ T-ville	(MR & CRS & DWR weather)
Indian @ Flournoy	(MR & CRS)
Indian @ DWR weir (abv Red Clover)	(MR & CRS)
Red Clover @ Chase Bridge	(MR)
Red Clover Cr @ Drum	(MR)
RC @ Notson	(CRS)
Last Chance Cr @ Murdock	(MR)
LC @ Doyle x-ing	(CRS & DWR weather)
McClellan Cr	(DWR)
Cottonwood Cr	(CRS)
Little Stoney Cr	(DWR)
Willow Cr	(DWR)
LC @ Alkali Flat low water x-ing	(DWR)
Ferris Cr	(DWR)
LC @ Bird-Jordan Neck	(staff gage & DWR)

Middle Fork Feather River watershed

Nelson Cr	(MR)
MFFR @ Sloat	(staff gage)
Jamison Cr	(MR)
Sulphur Cr @ Clio	(MR & CRS & volunteer weather station)
Boulder Cr	(staff gage)
Barry Cr	(staff gage)
Sulphur @ Lower Loop Bridge	(staff gage)
Sulphur @ Upper Loop Bridge	(staff gage)
MFFR @ Beckwourth	(MR)

Data Collected at the Continuous Recording Stations (CRS):

- Stage (calibrated to flow)
- Water Temperature
- Air Temperature
- Turbidity (NTU's) (Spanish at Gansner and Indian at Taylorsville only)

Continuously recorded flow data can assist in determining the ability of the watershed to store winter and spring precipitation, and release it later in the year. (Most of the CRM's restoration efforts are concentrated on restoring this function of the floodplains within the watershed.) Water temperature is a biologically important parameter to monitor because of its effect on native aquatic species. Campbell CR10X data loggers are installed at Red Clover Creek on Notson Bridge; Last Chance Creek at Doyle Crossing, and Million Dollar Bridge; Cottonwood Creek above and below Big Flat; Indian Creek at the DWR weir (abv Red Clover), at the Flournoy Bridge (blw Red Clover), and at the Taylorsville Bridge; Lights Creek at Deadfall Bridge; Wolf Creek at the Main Street Bridge in Greenville; Spanish Creek near Highway 70 at the Gansner Park Bridge in Quincy; and on Sulphur Creek at the Highway 89 Bridge. At these sites, stage, air and water temperature are read every 15 minutes, are stored as hourly averages, and then summarized into daily files at the end of each water year. Additionally, Analite 195 laser sensors (a nephelometric (n.t.u.) probe) were installed at the Taylorsville Bridge and Spanish Creek in 2001 to continuously record turbidity. The data loggers are capable of storing up to six months of data. FRCRM staff and contract technicians download data bi-monthly to ensure reliable station operation. Because of unstable channel dynamics at most of the stations monthly calibration measurements are required. Rating tables are reviewed and/or updated annually.

DWR Weather Stations

The Calif. Dept. of Water Resources has installed three weather stations recently in the area to assist in managing the Feather's water resources. The two Last Chance stations are accessible on the Calif. Data Exchange Center website (CDEC): Doyle Crossing (DOY), installed in spring 2000; and Jordan Peak (JDP) installed in fall 2004. The Taylorsville Station should be CDEC accessible this year. Data recorded at the stations include: rainfall, temperature, relative humidity, wind speed, wind direction, and atmospheric pressure.

RESULTS AND SIGNIFICANT FINDINGS

Some data are best analyzed through comparisons over time, and some between areas. It is important to put data compared over time in the context of annual climatological conditions. Table 1 compares precipitation in the water years covered by the FR-CRM's monitoring program. For comparison between years, 2005 and 2003 were used because of similar precip amounts.

Table 1. Precipitation averages

Water Year (10/1-9/30)	Percent of Historic Average annual precip for all Feather River Basin from CDEC*	Water Year (7/1-6/30)	Total annual precip (inches) at Indian Cr in Genesee (Wilcox data)
		1996	54.55
		1997	58.9
1998	144%	1998	60.70
1999	99%	1999	47.8
2000	101%	2000	43.65
2001	56%	2001	23.6
2002	77%	2002	33.6
2003	111%	2003	49.6
2004	83%	2004	42.8
2005	109%	2005	45.6
			46.1 = Avg

* calculated by averaging the percent average of all reporting stations in the watershed. For 2004 there were 6/10 stations with averages (Sierraville, Vinton, Portola, Chester, Strawberry Valley, Brush Cr). For 2005 there were 9/10 stations (all of the above, plus Greenville, Quincy, and DeSabla).

For purposes of this report, data were analyzed with the following specific questions in mind. The questions were formulated based on results and recommendations from the 2004 SWAMP report. They are all listed together here and then discussed in detail further below.

Last Chance Creek watershed:

1) Is there a significant difference between the peak flow decline in 2005 and 2003 at Doyle Crossing?
2) Is there an improvement in the peak flow decline and number of surface water days at Million Dollar Bridge between 2004 and 2005?
3) Is there a significant difference between the Last Chance and Red Clover falling peak flow decline in 2004 and 2005?
4) Is there a significant difference in Big Flat upper vs. lower gage readings in 2004 vs. 2005?
5) Is there an improvement in low flow conditions on Last Chance Creek at Doyle Xing?

Other sites:

6) Compare summer water temperatures at all sites.
7) Is Lights Cr flow still declining?
8) Are restoration projects contributing to a measurable increase (in the larger tributaries) of summer base flows?
9) Are restoration projects contributing to a measurable attenuation of peak flows (in larger tributaries)?

Last Chance Creek

In 2002-2005 the CRM implemented a nine-mile long restoration project in the upper Last Chance Creek watershed. It was hoped that such a large, landscape-scale restoration project would yield large ecosystem responses that smaller projects don't. Project level monitoring includes water temperature, channel morphology, vegetation, etc. that can be found in the Last Chance Creek Restoration Project Final Report on the FR-CRM website. The operation of two Continuous Recording Stations in the watershed were funded by the Forum in 2004 & 2005.

Peak Flow Attenuation at Last Chance

The first question (Is there a significant difference between the peak flow decline in 2005 and 2003 at Doyle Crossing?) addresses the expectation that 7.75 miles of floodplain restoration would show attenuated flood flows. The ideal comparison would be between 2005 and a pre-project year. However, not all data are available to make such a comparison. (Hourly data best show the rate of the falling limb, but hourly precip data are not available for 2000, the only other nearly comparable year). Table 2 shows that a significant portion of project work was completed between 2003 & 2005. Therefore, one might expect to see a change between these years.

Table 2. Completion of Project work at Last Chance Creek

Year	Reach Name	Miles of Channel	Affected Acreage
1995	Big Flat on Cottonwood Cr	0.78	47
2001	Stone Dairy	0.43	20
2002	Meadowview & Artray	1.6	300
2003-4	Ferris Field I, Alkali Flat, Bird, Bird-Jordan, Ferris Cr, Jordan Flat I	4.1	800
2004	Above Charles	0.38	80
	Big Flat Modification	0.57	34
2005	Jordan Flat Supplemental	0.34	50
	Dooley Cr	1	80

Figure 3 shows both precipitation and stage at Doyle Crossing for the peak flow events in 2003 and 2005. The 2003 peak occurred on March 15, and the 2005 peak occurred on March 28. The 2003 event shows a tight, or "flashy" response between the precip and the flow, which would be expected from an impaired watershed that does not absorb precipitation well. The 2005 stage peak occurs well after the 2005 peak precip event, in fact, the stage peaks during a lesser precip event. This may indicate that the watershed's ability to absorb precip has improved between 2003 and 2005. This conclusion, however, must be accepted with caution; the 2003 precip event was greater than the 2005, which would tend to cause a flashier response, and perhaps some of the 2005 attenuation was due to snow.

Dr. Levant Kavvas' (UC Davis) modeling work in the watershed suggested that the placement of the Doyle X-ing Monitoring Station may never show differences due to the Last Chance Project. The Doyle X-ing Station is about nine miles downstream of the project area, and in between the station and the project area are several subwatersheds with very shallow soils that naturally respond in a flashy manner to precipitation. However, since a good portion of the project was completed between these two years, it is not inconceivable that a difference might be discernable. (Project work is planned within the next three years for the remaining nine miles between the completed project area and the Doyle X-ing station.)

Question two; “Is there an improvement in the peak flow decline and number of surface water days at Million Dollar Bridge between 2004 and 2005?” uses data from higher in the watershed to answer the peak attenuation question. This station is within the project area, and therefore not subject to the influence of a large untreated section of watershed like the Doyle X-ing station is. Because the station is within the project area, however, it only monitors effects from the Meadowview, Artray, Bird, Bird-Jordan and Jordan Flat project reaches. It was installed as part of the UC Davis Modeling Study in 2004, and therefore has no pre-project data. A comparison between 2004 and 2005, however, may show the effects of the Jordan Flat Supplemental project, which was constructed in 2004. Indeed, Figure 4 does show a longer flow duration of one week, as well as more water in ’05 vs. ‘04. The difference may also be attributed to the still-improving ability of the other restored meadows to absorb and release precipitation a couple of years after restoration. This would be expected as riparian vegetation begins to regain vigor, and assist in soil porosity. Again, however, the conclusion must be cautious because 2005 was a bigger water year. (However, late season precipitation was comparable between the two years.)

Question three looks at peak attenuation through a comparison <u>between</u> two watersheds - Is there a significant difference between the Last Chance and Red Clover peak flow decline in 2004 and 2005? The expectation is that Last Chance Creek would show an improving trend in peak attenuation compared to Red Clover Creek, which is largely untreated (one half mile of Bagley Creek was treated in 1993 & 1996). Figures 5 & 6 show the peak hydrograph for the two stations (Doyle X-ing on Last Chance and Notson Bridge on Red Clover) in 2004 and 2005, respectively. Comparison between the two watersheds is somewhat difficult due to the large difference in flow quantity, as well as greater forested cover in the Red Clover watershed. However, both are large eastside watersheds, and probably the most appropriate comparison available.

The 2004 hydrograph (Fig. 5) shows an interesting difference in peak between the two watersheds. The Last Chance peak is later. This could be due to restored floodplains absorbing the February precipitation, or, perhaps a precip or temperature difference between the two watersheds in February. The two watersheds respond similarly in the March peak. The 2005 comparison (Fig. 6) required using a pre-peak storm in early March, because the gage has not been rated for the annual peak flows at Notson Bridge on Red Clover Creek. Because of the lack of peaks on even this smaller storm, diurnal flow cycles were analyzed. The rate of decline of each falling limb per diurnal cycle was compared (i.e. the change in cfs per hour). The rate was calculated by subtracting the lowest flow of the cycle from the highest flow of the cycle. That difference was then divided by the number of hours between the peak and the nadir. Table 3 shows a numerical comparison of this rate. The rate of decline is slower for every limb but the first one. One would expect the larger watershed (Red Clover Creek) to decline more slowly. Perhaps the slower decline in Last Chance is due to improved water retention in the watershed from the Last Chance project work?

Table 3. Analysis of the rate of decline of the diurnal falling limbs on Last Chance vs Red Clover Creek March 4-18, 2005. See Figure 6 as well.

Date	Red Clover (cfs/hr)	Last Chance (cfs/hr)
3/4-3/5	1.0	1.2
3/5-3/6	1.7	1.4
3/6-3/7	1.6	1.3
3/7-3/8	2.7	1.8
3/8-3/9	3.0	2.3
3/9-3/10	4.4	2.6
3/13-3/14	5.6	2.2
3/14-3/15	3.9	1.8
3/15-3/16	3.9	1.0
3/16-3/17	1.4	0.8
3/17-3/18	1.3	0.9

The fourth question: "Is there a significant difference in Big Flat upper vs. lower gage readings in 2004 vs. 2005?" again looks at the capability of the watershed to absorb peak flows and release those flows later in the season. Big Flat data, however, covers a much smaller area; just that within the Big Flat project area. Big Flat is located in the Last Chance Creek watershed. Since it was the first pond-and-plug project to be implemented by the CRM, project-specific continuous flow and temperature recorders were installed to monitor success (one above, and one below the project).

Figure 7 shows monitoring of surface flow at the bottom end of the project area from before the project, up to the present. The chart seems to indicate that the meadow stored precip and released flows, even as precip decreased up through 1999. Please note that the precip in those years was steadily above normal. Once precipitation began to approach and than drop below normal, surface flow out of the project area also suffered. Another perhaps causal factor contributing to the decline of surface flow in 2000 onward is the downcutting of the restored channel. In 2004, the Plumas County Resource Advisory Committee funded a modification project at Big Flat which entailed the installation of 64 riffles, which effectively raised the base elevation of the channel back up to the meadow surface. The increase in 2005 flow duration vs 2004, with only a slight increase in precipitation may suggest that the riffle augmentation project restored the storage and release function of the meadow.

A comparison between 2003 and 2005 would be expected to show a greater attenuation of peak flows and a longer seasonal duration of surface flows after the repair work. However, Figures 7 & 8 both show longer flow duration in '03 vs. '05. This is probably due to greater precip in '03 vs. 05. Hopefully, 2006 data (an above normal precip year) will show a much longer duration of surface water.

Base Flow Augmentation at Last Chance

Another expected result of floodplain restoration projects is improved base flow, which is expected from the release of shallow groundwater storage that soaked into the floodplains during winter precipitation. This is addressed by Question 5: Is there an improvement in low flow conditions on Last Chance Creek at Doyle Xing? As with peak flows, we attempted to answer this question, by comparing 2003 base flows to 2005. The wild card in this process, however, is evapotranspiration (ET) from the vegetative response to the higher water table. Researchers from UC Davis and Stanford University have conducted studies within the Last Chance project area, with one objective (of several) of quantifying water loss due to evapotranspiration. UC Davis includes a leaf index in the Water Environmental Hydrology Model (WEHY), but their modeling work on Last Chance Creek could not explain an unbalanced water budget. They suggested that some water loss could be due to ET, or possible deep aquifer recharge. The Stanford work, by Steve Loheide, using thermal infrared imagery and continuous recording monitoring wells also attempted to quantify ET. A paper on his results is expected in Spring 2006. The CRM has not attempted to measure ET. It is notoriously difficult to quantify.

Our continuous recording stations, however, provide year-round measurement of flow. The expectation is to be able to see a change in base flow over time. To tie base flow changes to project work, however, is difficult, because of climatological differences between pre- and post-project years, as well as the 10-15% error margin in flow data, that is especially apparent at low flows. Summer flow conditions depend particularly on spring precipitation and summer air temperatures. Finding two comparable years with our limited data set is difficult.

Figure 9 shows a comparison of 2003 and 2005 low flows, and shows August base flow lower in 2005 than in 2003; the opposite of what would be expected from restoration work. (For context, figures 10 & 11 show the high and low temperatures in each year (WY 2003 was hotter), and figures 12 & 13 show the precipitation of each year.) What could explain lower base flow in 2005? It could be climatological – there was more August precip in 2003 than in 2005, and significant drops in the daily high air temperature in 2003 (Fig.10). It should also be noted from Table 2, that while the overall Feather River watershed precip difference between 2003 & 2005 was only 2%, there was almost 10% less annual precip in 2005 than 2003 at Doyle X-ing. Figure 9 also shows that around mid-September, when vegetation begins to wilt, the 2005 base flow markedly increases. This suggests a substantial loss due to evapotranspiration throughout the watershed. (Although the base flow increase was also accompanied by a precip event.) When trying to maximize surface water, however, it is important to keep all phases of the water cycle in mind. If there is renewed evaporation out of the Last Chance watershed, is this considered a loss? or restoration of an important cycle?

<u>Other Sites</u>

Temperature

The Regional Water Quality Control Board has identified water temperature as a concern in the Feather River. Water temperatures were compared between sites, and between years at each site to track trends in this water quality parameter.

Table 4 displays water temperature data from each of the ten continuous recording stations by year. Definitions of the summary statistics are:

Absolute daily MAX water temp = The highest 1 hour-long temperature that was recorded during the sampling period

MAX 7-day avg of daily avg = A running 7-day average was calculated throughout the sampling period. This column displays the highest of those seven-day averages.

 # 7-day averages >66F = This column displays the number of running seven day averages that were greater than 66 degrees Fahrenheit. The importance of this parameter is biological, in that if the water is an average temperature greater than 66F for seven days, it is probably not conducive to a coldwater fishery.

 # days with max >75F = This column displays the number of days that had an absolute 1-hour long temperature greater than 75F. The importance of this parameter is also biological, in that if the water is even has a short-term maximum greater than 75 degrees Fahrenheit, then it is probably not conducive to a coldwater fishery.

Max summer diurnal fluctuation = This column shows the greatest fluctuation in temperature in a 24-hour period during the sampling period.

Data days – This column shows the dates of the sampling period, and is important to note in comparisons between years. Some stations have incomplete data.

Table 4 shows that Last Chance Creek at Doyle Crossing, and Lights Creek continue to be the two most heavily temperature impaired channels. To better see trends, summary statistics are graphically displayed in Figures 14-17 for stations with available data. The expectation is that as restoration proceeds, temperatures would decrease.

Figure 14 shows maximum daily water temperatures at each station with usable low flow data. 2003 is the warmest year. Wolf Creek appears to show a fairly steady decrease in maximum daily water temperatures between years (data not available for 2005). This could be due to a combination of factors such as the increase in riparian vegetation from drought years and the CRM's restoration projects above the gage in 1999 (Dunham bank 0.04 miles), 2002 (Anson bank, 0.04 mi), and 1992 (Wolf Cr Phase 3), as well as beaver dams throughout the reach, one of which has increased water depth at the sensor. Sensor error, at this station, also cannot be ruled out. (Is increased beaver activity at Wolf Cr due to stabilizing effects of the 1990's restoration work?) Red Clover remains fairly stable throughout the years. The relationship between Indian above Red Clover, Indian below Red Clover, and Red Clover itself suggests a strong warming influence on water temperatures in Indian Cr from Red Clover Cr.

Figure 15 shows the maximum weekly average water temperatures. This parameter does not particularly show a trend at any station, but does show Lights and Last Chance Creeks as the two warmest channels. The severity of impairment, and its impact on trout fisheries, is shown in Figures 16 & 17. Both charts show Last Chance and Lights Creek again as the most impaired waters for a trout fishery, with Wolf Creek and Indian Cr blw Red Clover showing steady improvement. Indian above Red Clover only shows up as one blip in 2001in Fig. 16, meaning that this segment of Indian Cr is more conducive to trout than it is after it joins with Red Clover. After it joins with Red Clover, Indian shifts back and forth between years of impairment and no impairment. Last Chance and Lights Creeks tend to show up every year with more impairment than the other waters. While it is tempting to say that the declining max daily water temperature (Fig 14) and number of days above 75F (Fig 17) in Last Chance between '03 and '05 is due to restoration, it is probably due more to a cooling trend in summer air temperatures in the same time period. Untreated Red Clover shows a similar trend.

Figure 18 displays maximum summer diurnal fluctuation. This parameter is best suited for comparison between years at the same site, not between sites, because it appears to be heavily dependent on volume of water and elevation. The only site in Figure 18 that shows a definite trend, again, is Wolf Creek, as discussed above.

Lights Cr Flow

Flow in Lights Cr appeared to be declining in 2001 to 2003 despite increasing precipitation. A question posed in data analysis for 2004 & 5 was whether or not the weekly average minimum flow at Lights Creek still appeared to be declining. Lights Creek does not show a continuation of that trend (see Table 5).

All Station Flow

Questions 8 & 9 refer to flow:
- Are restoration projects contributing to a measurable increase (in the larger tributaries) of summer base flows?
- Are restoration projects contributing to a measurable attenuation of peak flows (in larger tributaries)?

Flow data contribute to the CRM's understanding of how the major tributaries contribute to flows in the larger systems, such as Indian Creek (i.e. timing and volume). Table 5 shows an annual summary of flow data for each station. Figure 19 graphically displays the minimum flows at each station by year. Flows generally follow the water year pattern, more flow with normal or above precip, and less flow with less precip.

The appearance of higher flows in Wolf may reflect the need for more calibration readings at this station. Also, in 2001, 2002 & 2004, when Indian above Red Clover shows more flow than Indian below Red Clover, there may be a transducer or calibration problem at one or both of those sites. (The blw Red Clover transducer will be replaced in 2006.) Figures 20-36 show the annual hydrograph and precipitation for 2004

& 2005 for each station. Similar graphs per station are available in the 2003 SWAMP final report for 2001-2003. These data are particularly difficult to analyze due to the stochastic nature of precipitation events, both temporally and spatially (especially in the mountains), the effects of temperature (rain vs. snow precip), and the saturation condition of the watershed. Peak hydrographs for Last Chance were analyzed more closely above. Data for other sites will become particularly valuable as the projects are complete above those sites. Figure 37 is a schema that shows projects completed and planned above each site.

2005 New Year's Eve Flood

This particular event was calculated by Jim Wilcox to be a 15-20 year return interval event in the Indian Cr watershed (23,000 cfs). Terry Benoit calculated it as a 10-yr event in the Spanish Cr watershed (13,500 cfs). Because of the infrequency of the event, as much monitoring was completed as possible, but not as much as we would have liked. Perhaps the CRM agencies should consider developing an inter-agency event monitoring plan that is triggered when an event happens. Attachment 1 is a summary of the monitoring from that event. Some flows will be calculated this summer when cross-sections can be surveyed for the slope-area method of discharge estimation. Peak flows were too high for measurement with our equipment.

CONCLUSION

The difficulty with watershed-wide data such as these, is that while project areas may indeed improve in temperature, segments of impaired channel may negate those improvements when it is measured at the station. However, it is important to keep in mind that the point of the watershed monitoring program is to ascertain changes on the large landscape level. The schema at the end of this report (Figure 37) shows the watershed area, and projects completed above each monitoring station. Much work needs to be completed to expect to see changes at the watershed scale. However, the placement of the stations allows monitoring at various distances from project work. The Wolf Creek and Last Chance at Million Dollar Bridge stations, for example, are within project areas. The Last Chance at Doyle X-ing station is nine miles downstream from a large-scale project. Nothing in the Lights Cr watershed has been treated. The Indian Cr stations generally have a large ratio of untreated to treated watershed areas above them. The Sulphur Creek and Spanish Creek stations are both collecting valuable pre-project data before landscape-scale projects are begun in those subwatersheds.

As mentioned in the beginning of this report, cause and effect cannot be concluded with confidence at this point from monitoring at such a large scale. Hopefully, a longer duration of the data set will continue to show watershed-wide improvements from strategically placed restoration projects. The cost-effectiveness of the continuous recording stations should ensure our ability to continue to operate them well into the future.

ACKNOWLEDGEMENTS

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Figure 1. Location of Continuous Recording Stations.

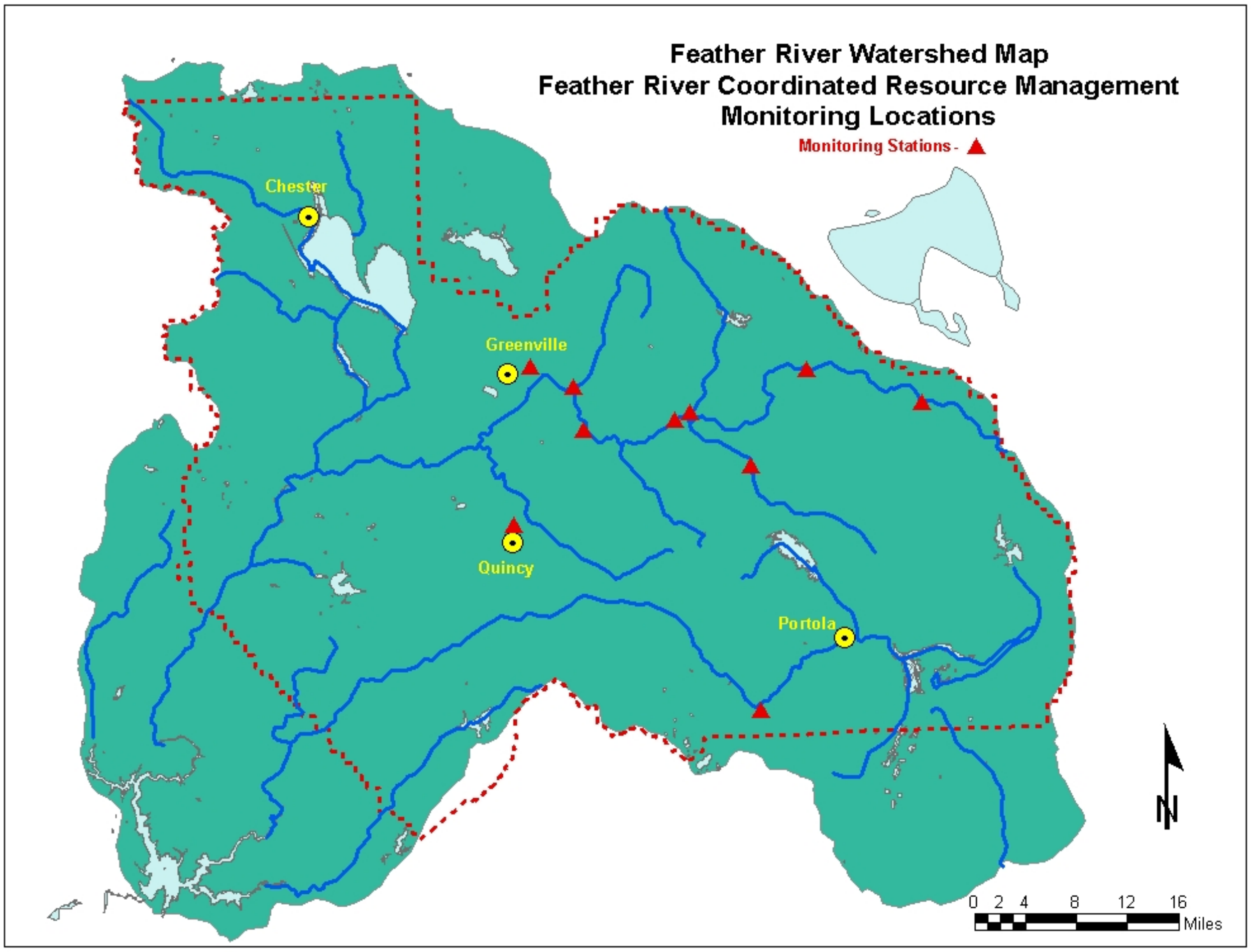
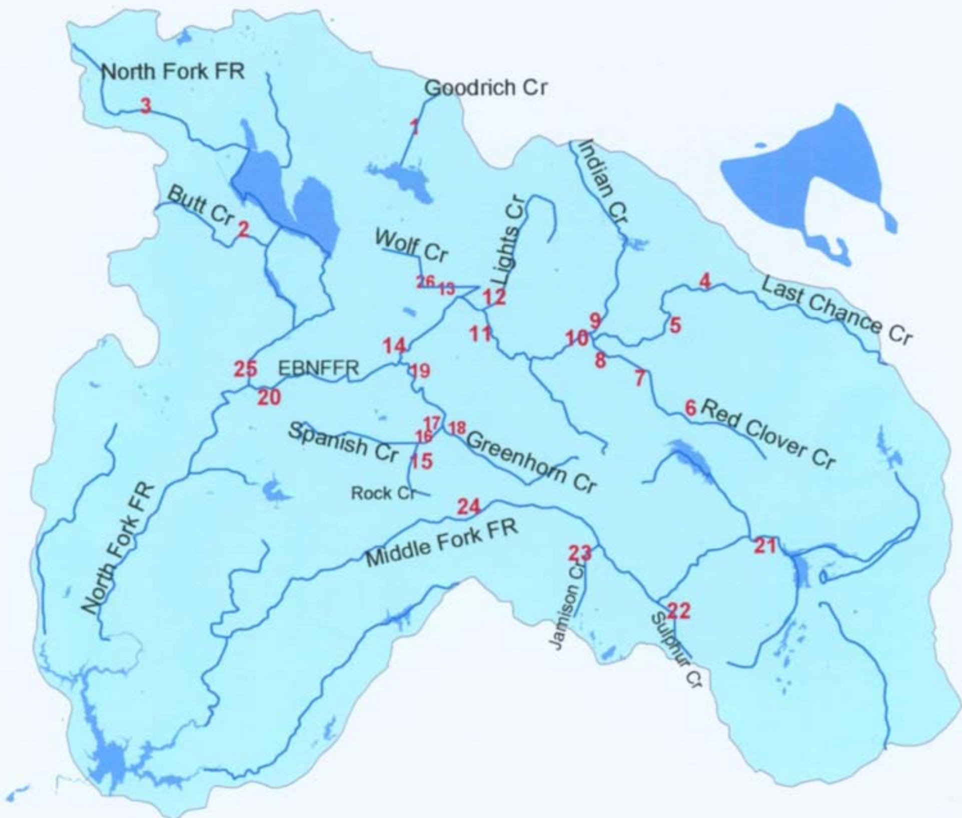


Figure 2. All Monitoring Locations.

Figure 2.

Upper Feather River Watershed Monitoring Locations



1. Goodrich Cr
2. Butt Cr
3. NFFR abv Lake Almanor
4. Last Chance Cr @ Doyle Crossing (CRS)
5. Last Chance Cr blw Murdock Crossing
6. Red Clover Cr blw Chase Bridge
7. Red Clover Cr at Notson Bridge (CRS)
8. Red Clover Cr blw Drum Bridge
9. Indian Cr abv Red Clover (DWR weir)
10. Indian Cr blw Red Clover (Flournoy)
11. Indian Cr at Taylorsville
12. Lights Cr
13. Wolf Cr near Town Park
14. Indian Cr abv Spanish Cr
15. Rock Cr
16. Spanish Cr at Hwy 70 (Gansner Park)
17. Spanish Cr abv Greenhorn
18. Greenhorn Cr
19. Spanish Cr abv Indian
20. East Branch North Fork Feather abv NFFR
21. Middle Fork Feather @ Beckwourth
22. Sulphur Cr
23. Jamison Cr
24. Middle Fork Feather abv Nelson Cr
25. North Fork Feather
26. Wolf Cr @ Main St Bridge

Figure 3. Doyle X-ing Hourly Stage & Precip 3/13-3/31 2003 & 2005

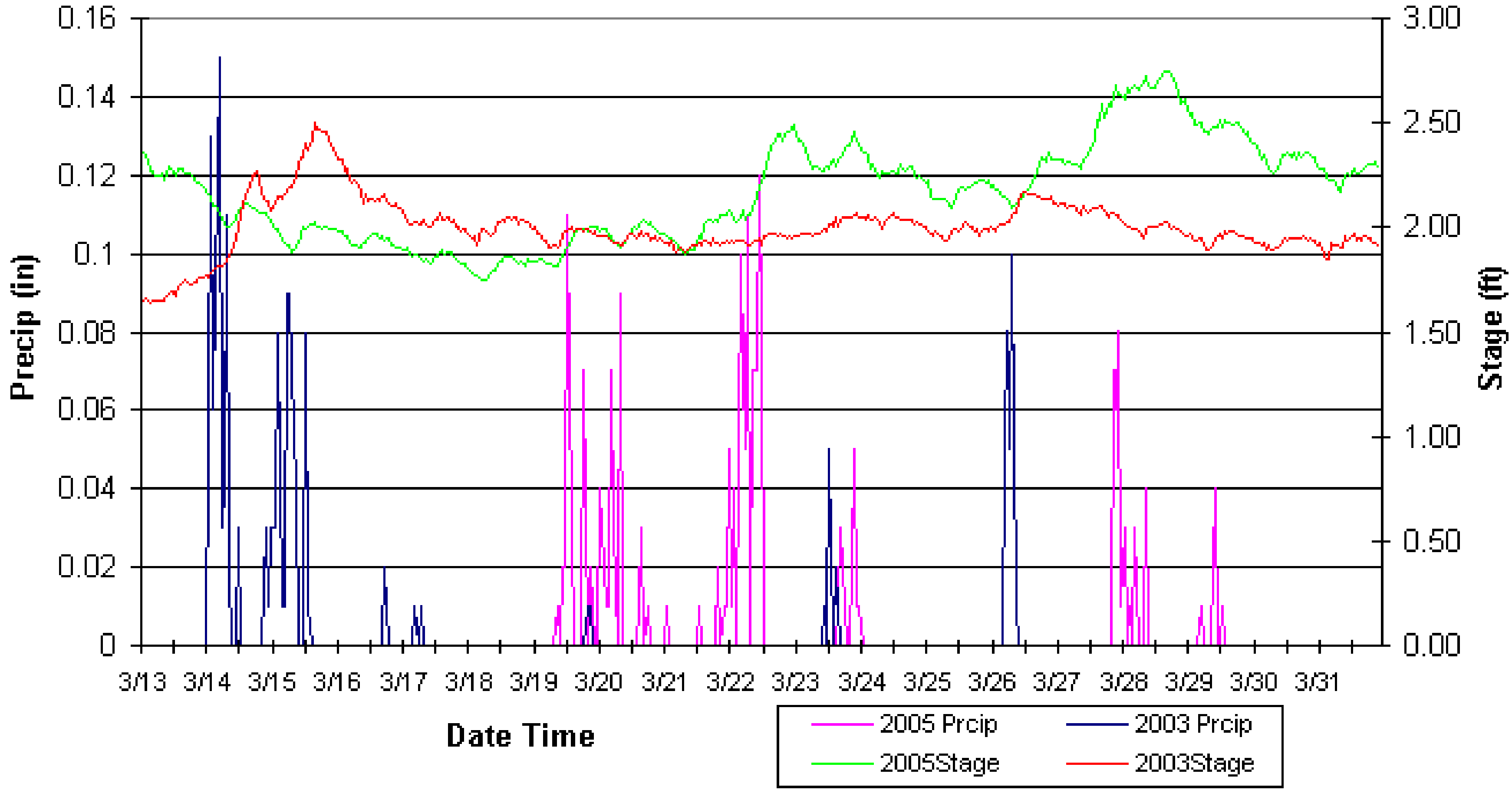


Figure 4. Last Chance at Million $ Br Flow & Precip Spring-Summer 2004-2005

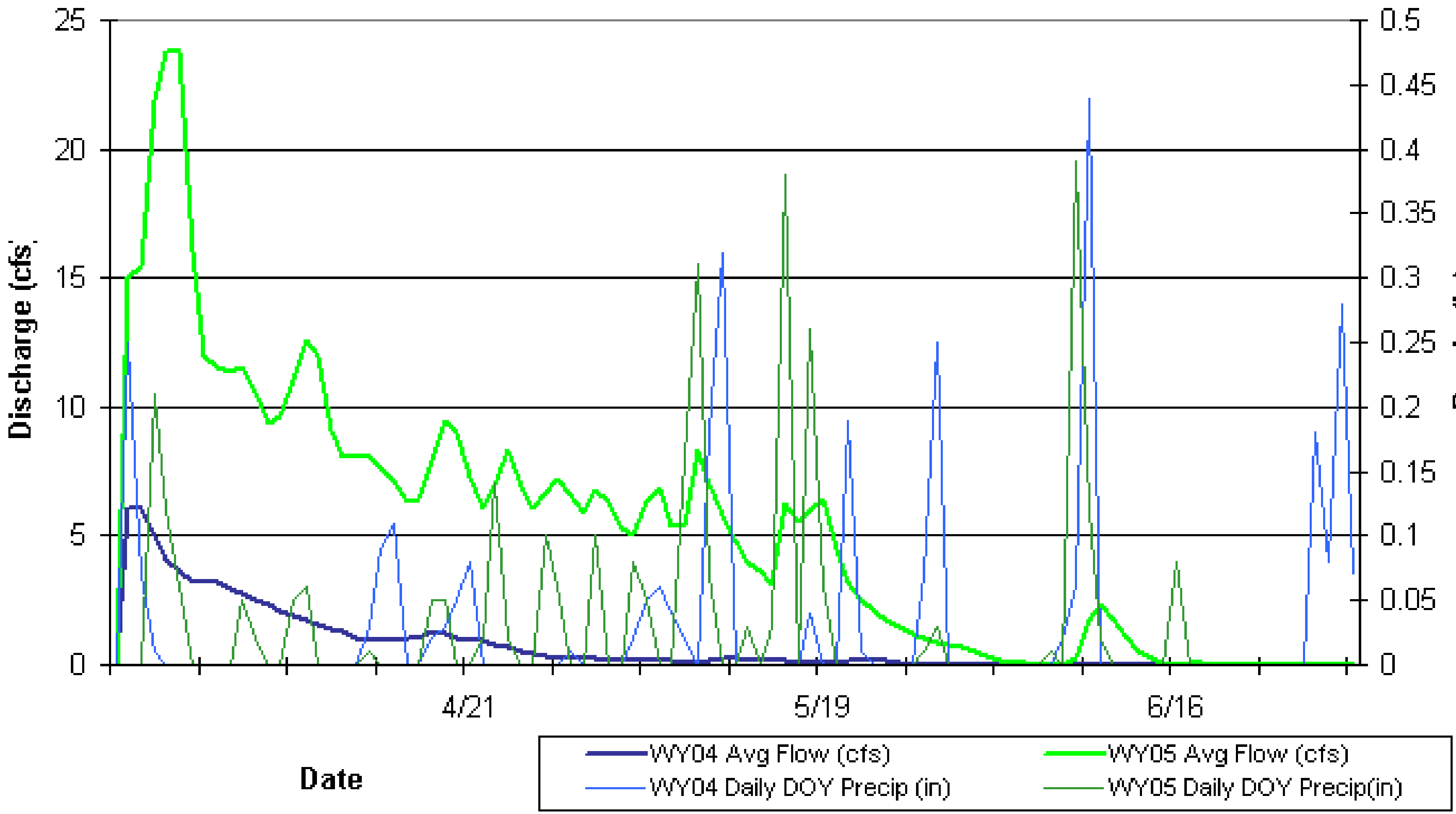


Figure 5. Last Chance (blue) vs Red Clover (red) Peak Discharge Hydrograph 2/15-4/15/04

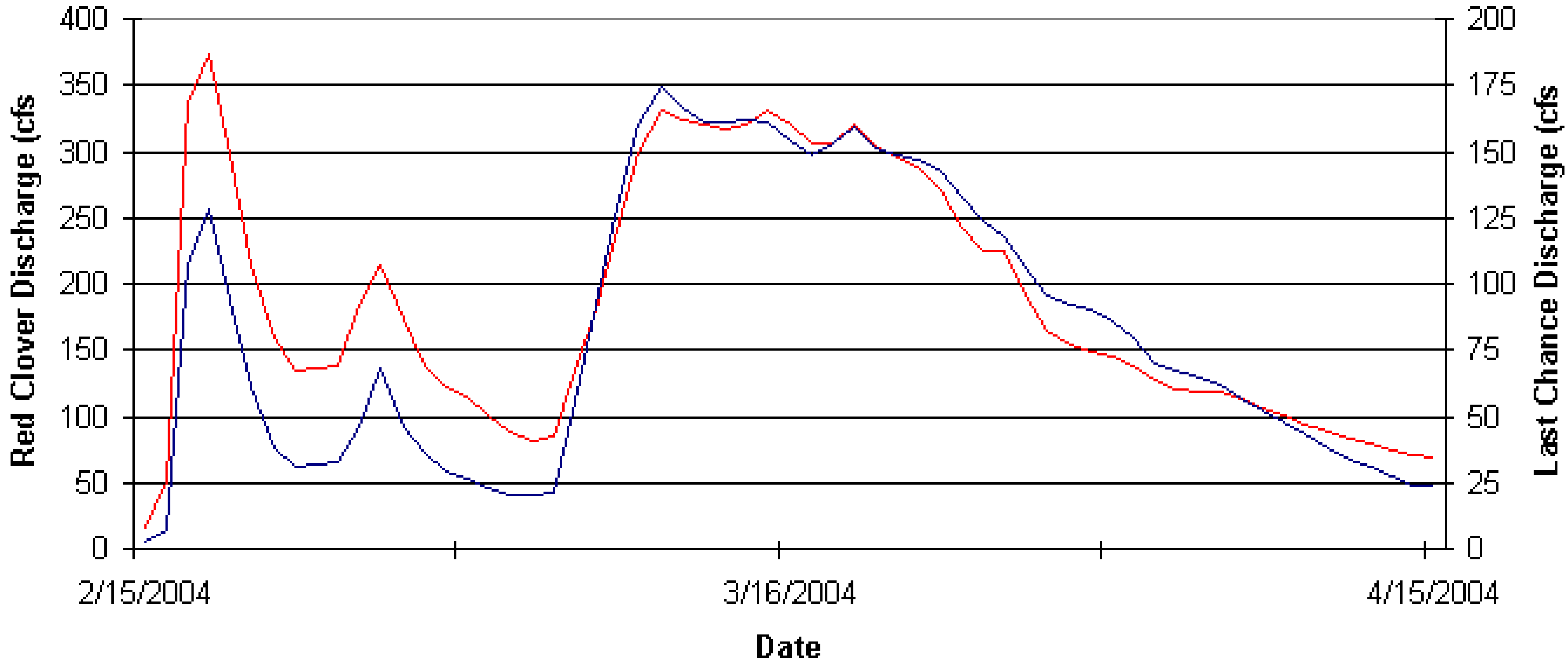
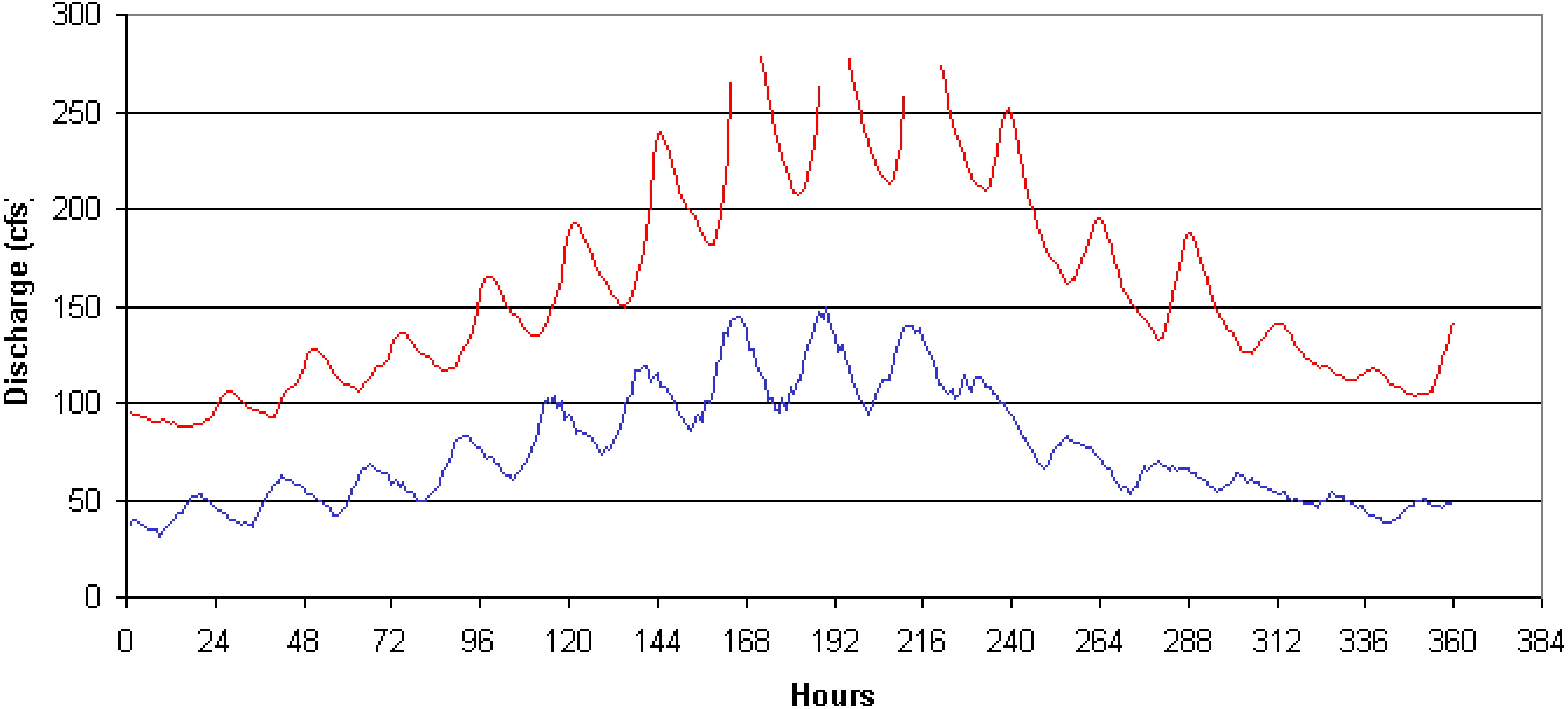
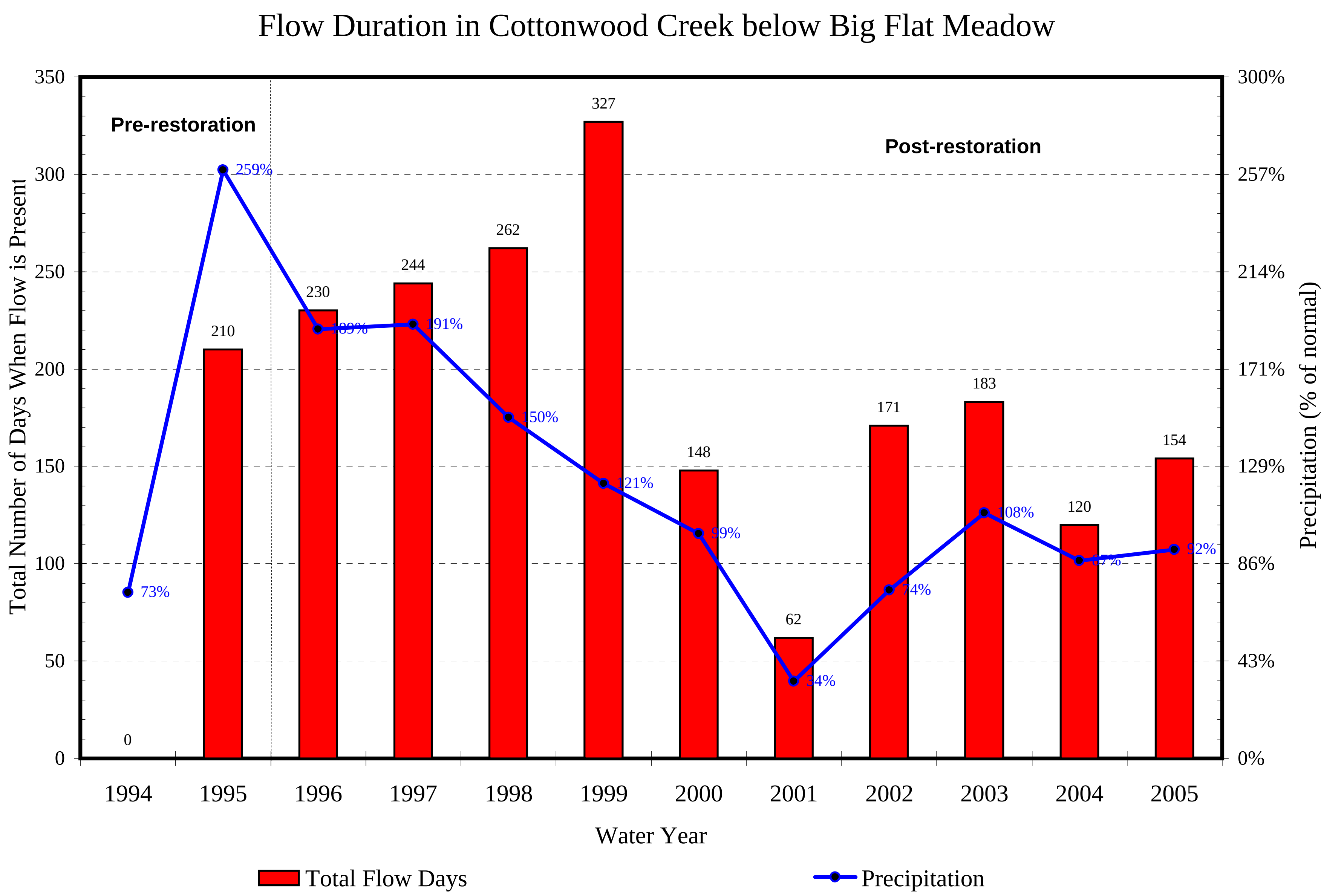


Figure 6. Last Chance (blue) vs. Red Clover (red) First Storm Hydrograph 3/4-3/18/05




Flow Duration in Cottonwood Creek below Big Flat Meadow
Pre-restoration
Post-restoration
Total Number of Days When Flow is Present
Precipitation (% of normal)
0
50
100
150
200
250
300
350
0%
43%
86%
129%
171%
214%
257%
300%
0
210
230
244
262
327
148
62
171
183
120
154
73%
259%
189%
191%
150%
121%
99%
34%
74%
108%
87%
92%
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
Water Year
Total Flow Days
Precipitation

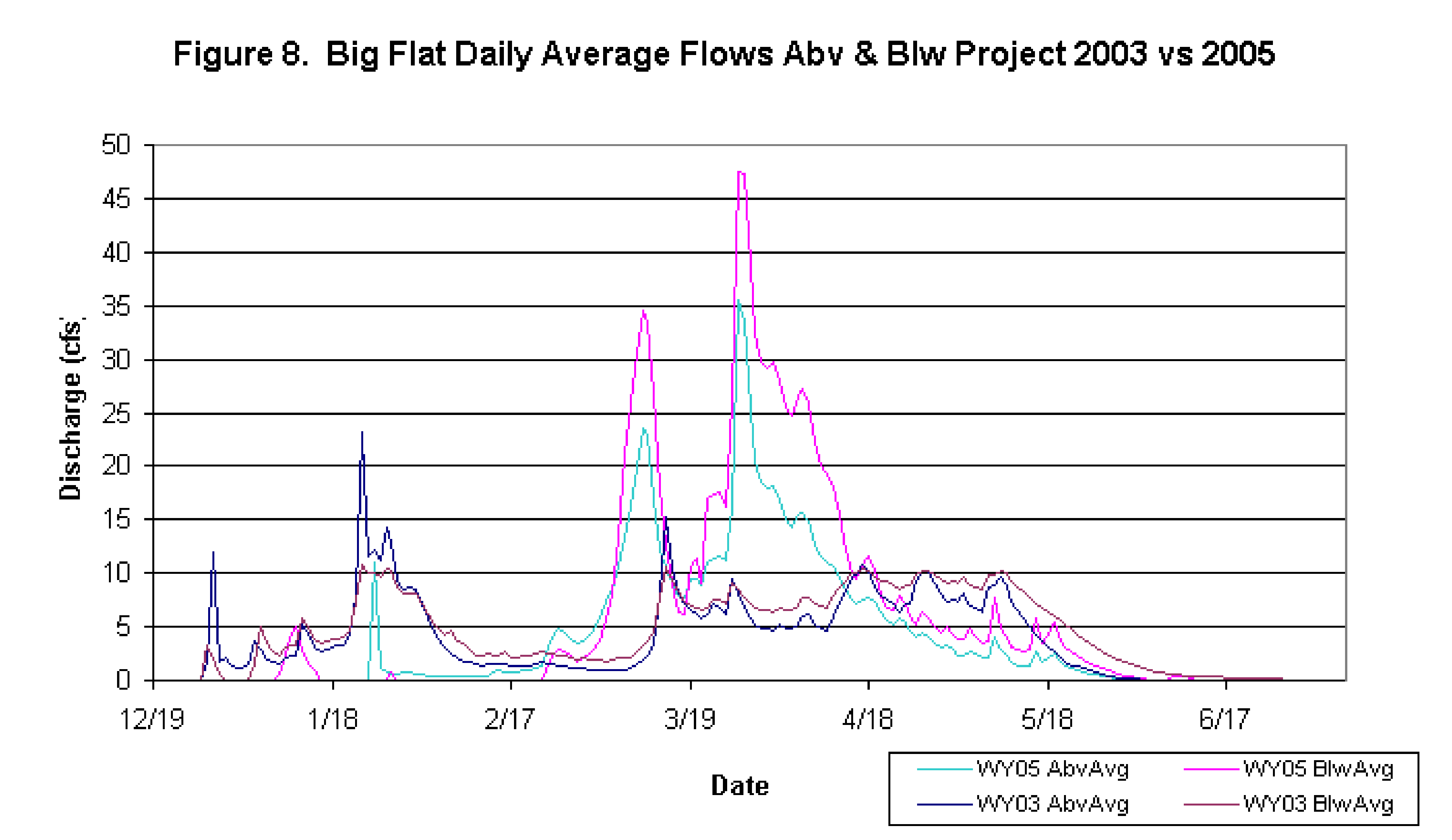
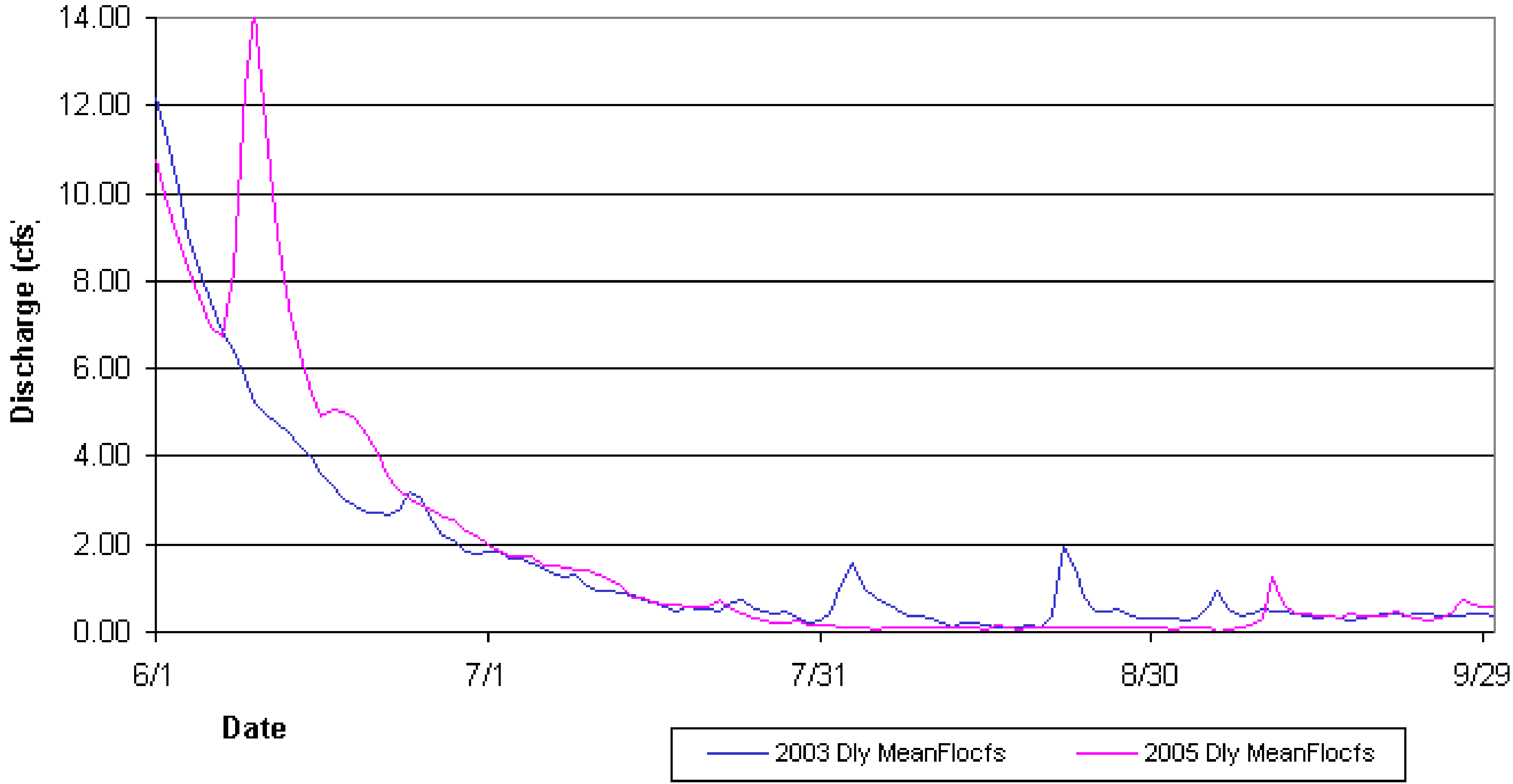


Figure 8. Big Flat Daily Average Flows Abv & Blw Project 2003 vs 2005
Discharge (cfs)
50
45
40
35
30
25
20
15
10
5
0
12/19
1/18
2/17
3/19
4/18
5/18
6/17
Date
WY05 AbvAvg
WY05 BlwAvg
WY03 AbvAvg
WY03 BlwAvg

Figure 9. Daily Avg Flow Last Chance at Doyle X-ing Summer 2003 vs 2005



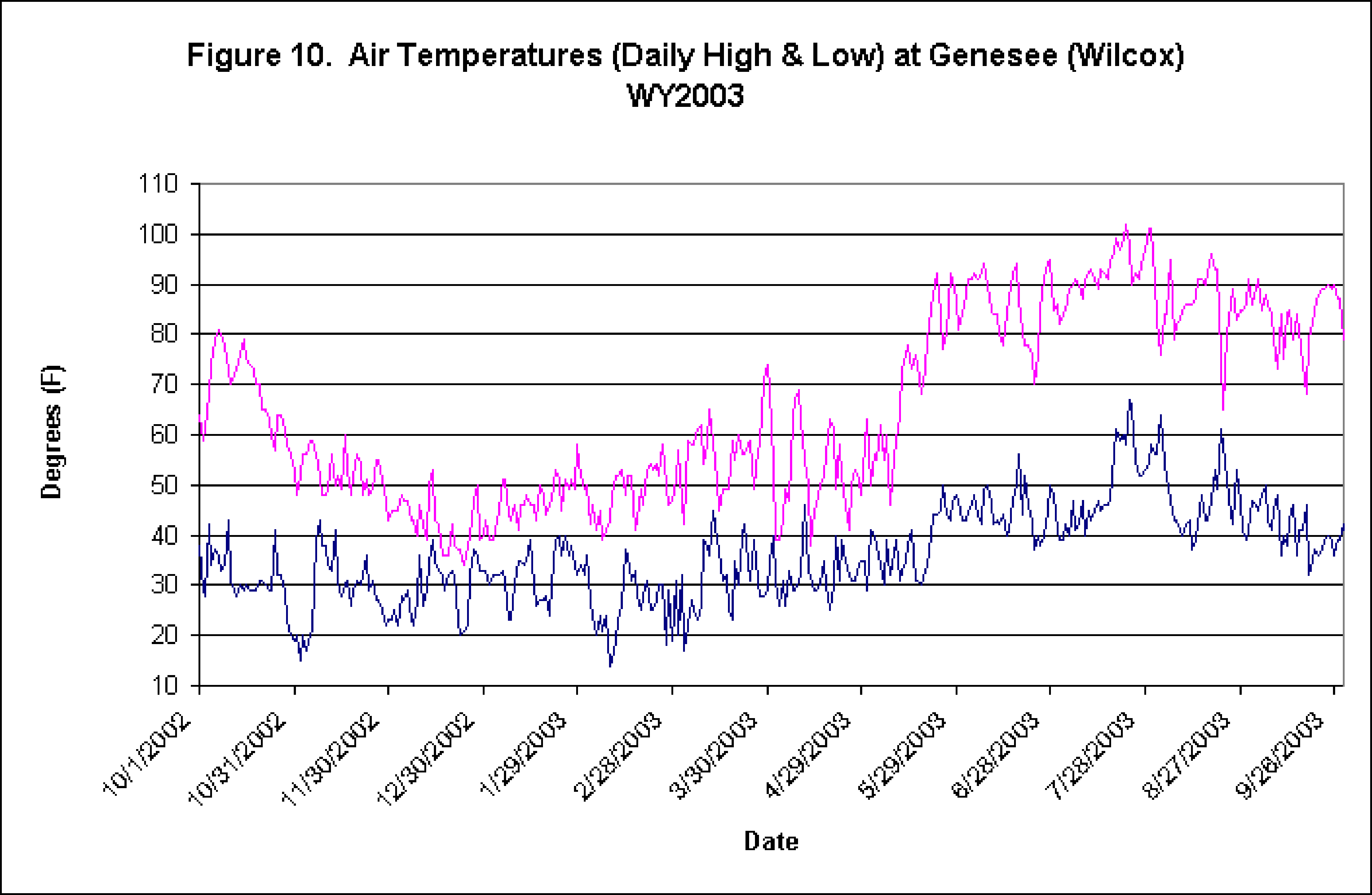
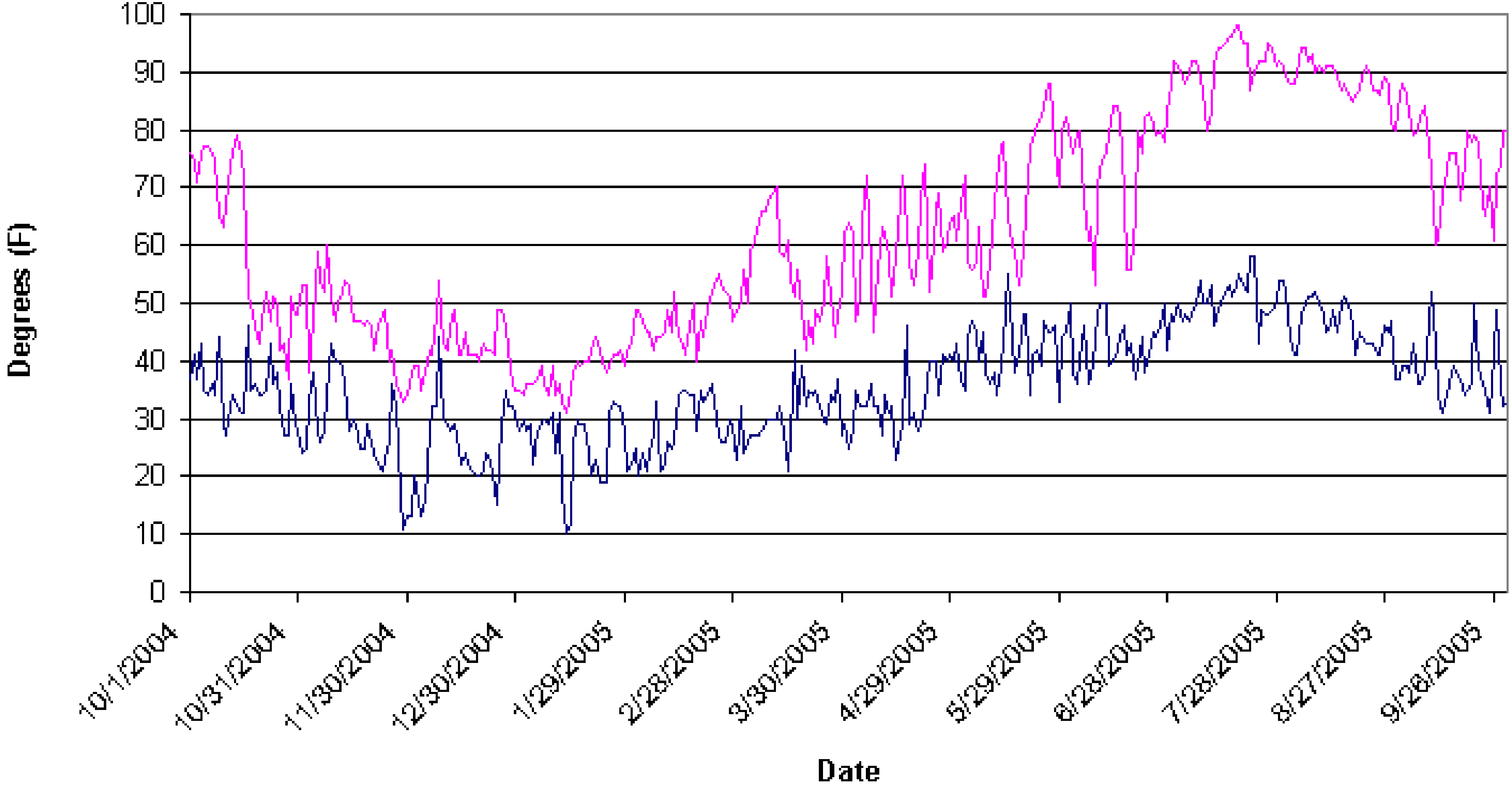


Figure 10. Air Temperatures (Daily High & Low) at Genesee (Wilcox)
WY2003
110
100
90
80
70
60
50
40
30
20
10
Degrees (F)
10/1/2002
10/31/2002
11/30/2002
12/30/2002
1/29/2003
2/28/2003
3/30/2003
4/29/2003
5/29/2003
6/28/2003
7/28/2003
8/27/2003
9/28/2003
Date

Figure 11. Air Temperatures (Daily High & Low) at Genesee (Wilcox) 2004-2005



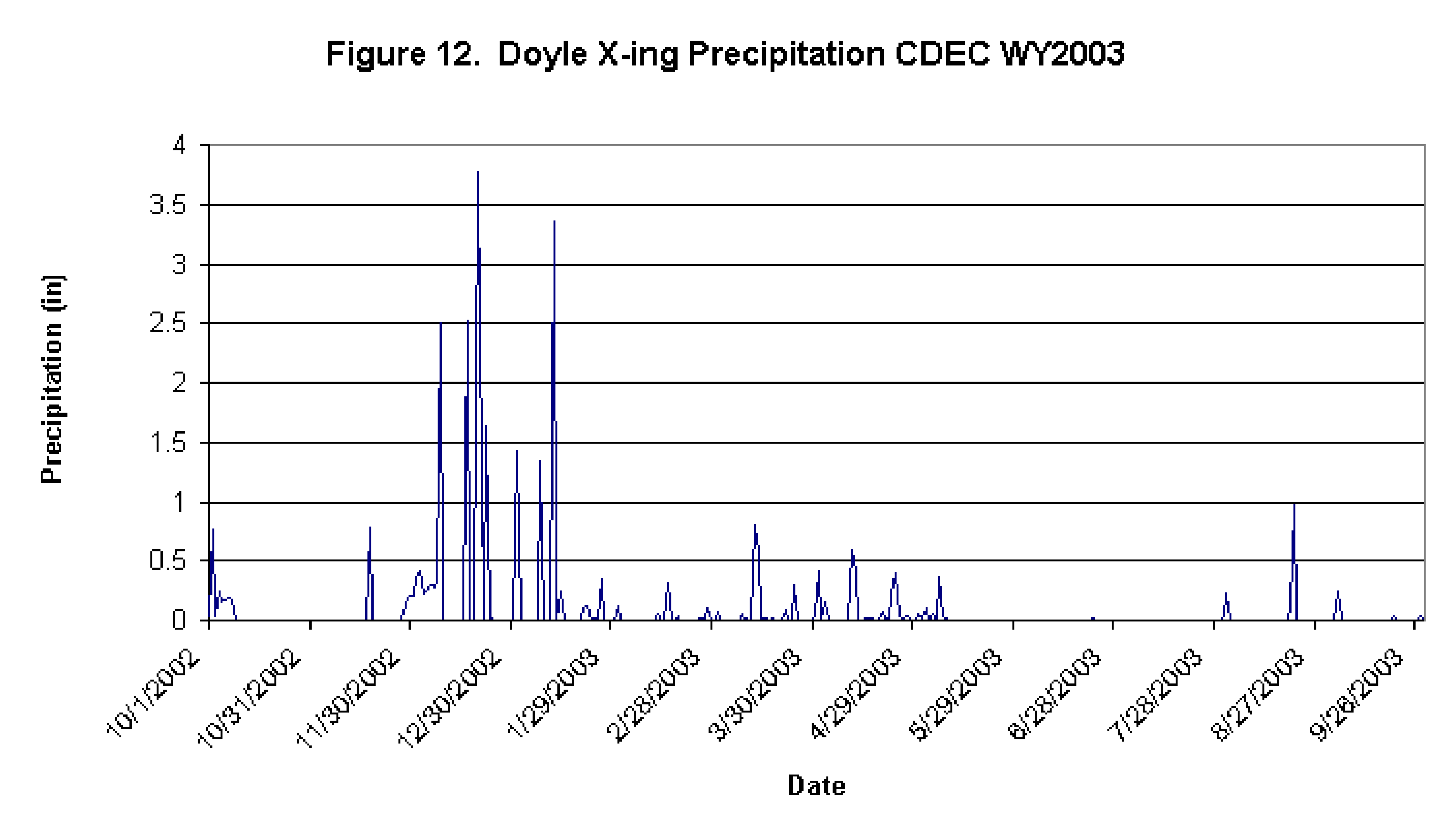
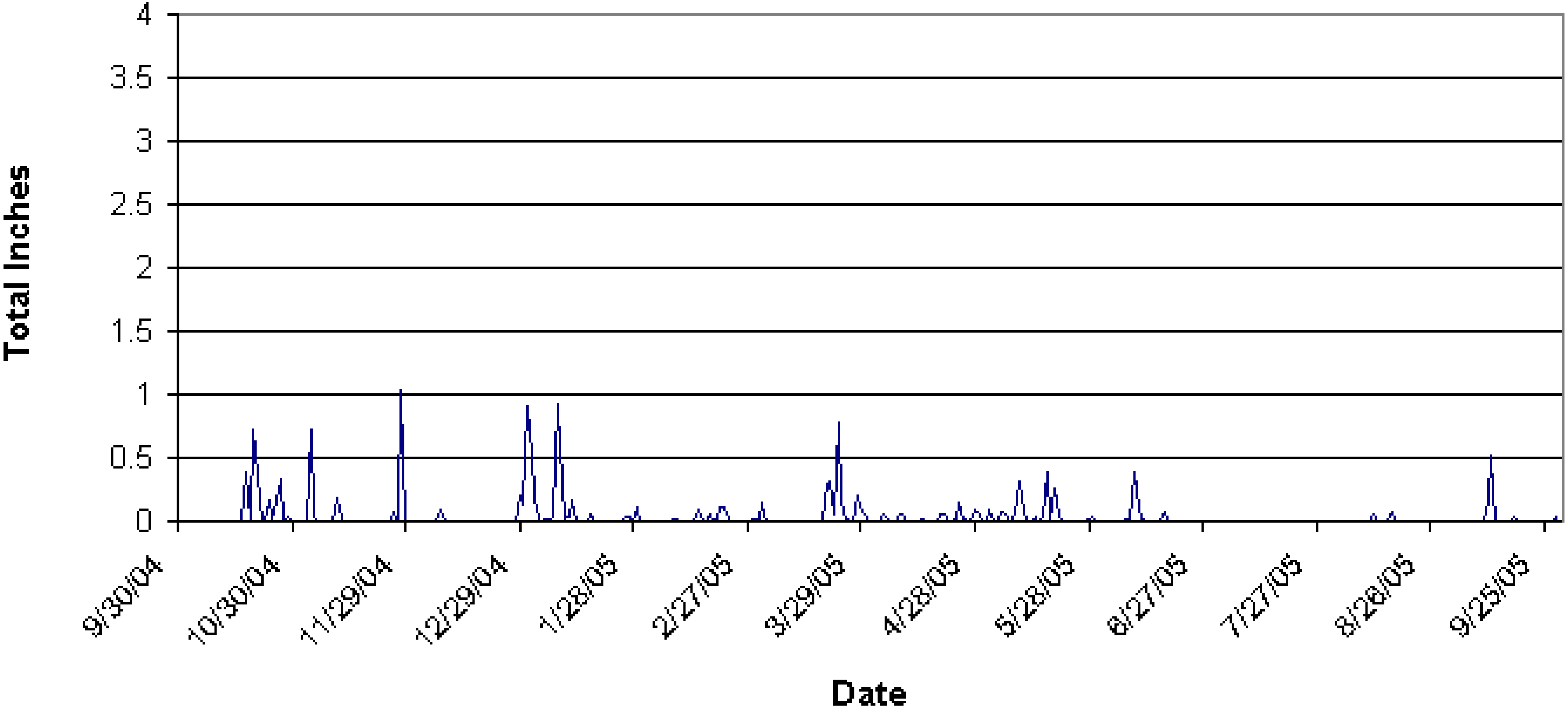


Figure 12. Doyle X-ing Precipitation CDEC WY2003
Precipitation (in)
4
3.5
3
2.5
2
1.5
1
0.5
0
10/1/2002
10/31/2002
11/30/2002
12/30/2002
1/29/2003
2/28/2003
3/30/2003
4/29/2003
5/29/2003
6/28/2003
7/28/2003
8/27/2003
9/26/2003
Date

Figure 13. Doyle X-ing Precipitation CDEC WY2005



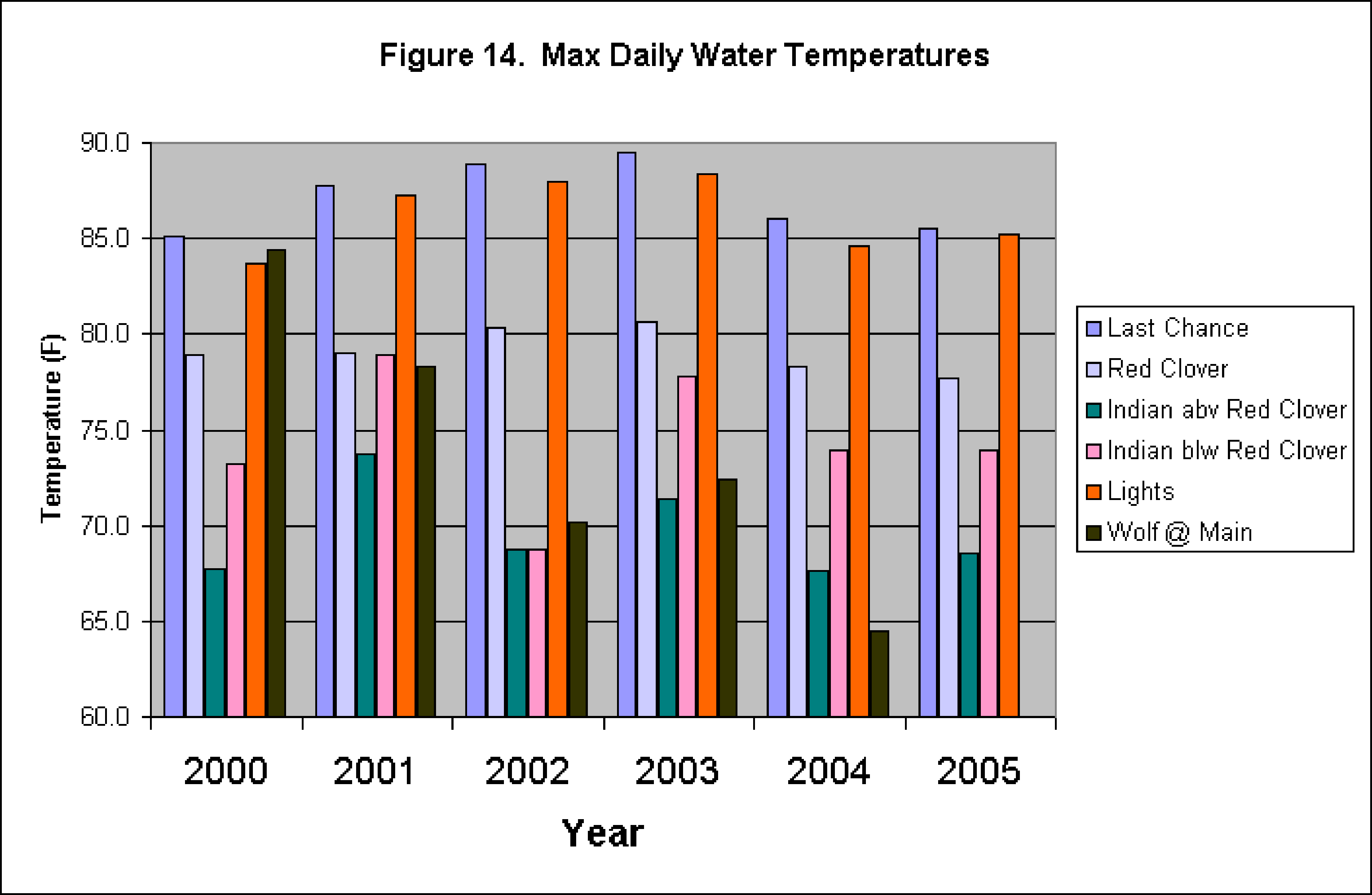
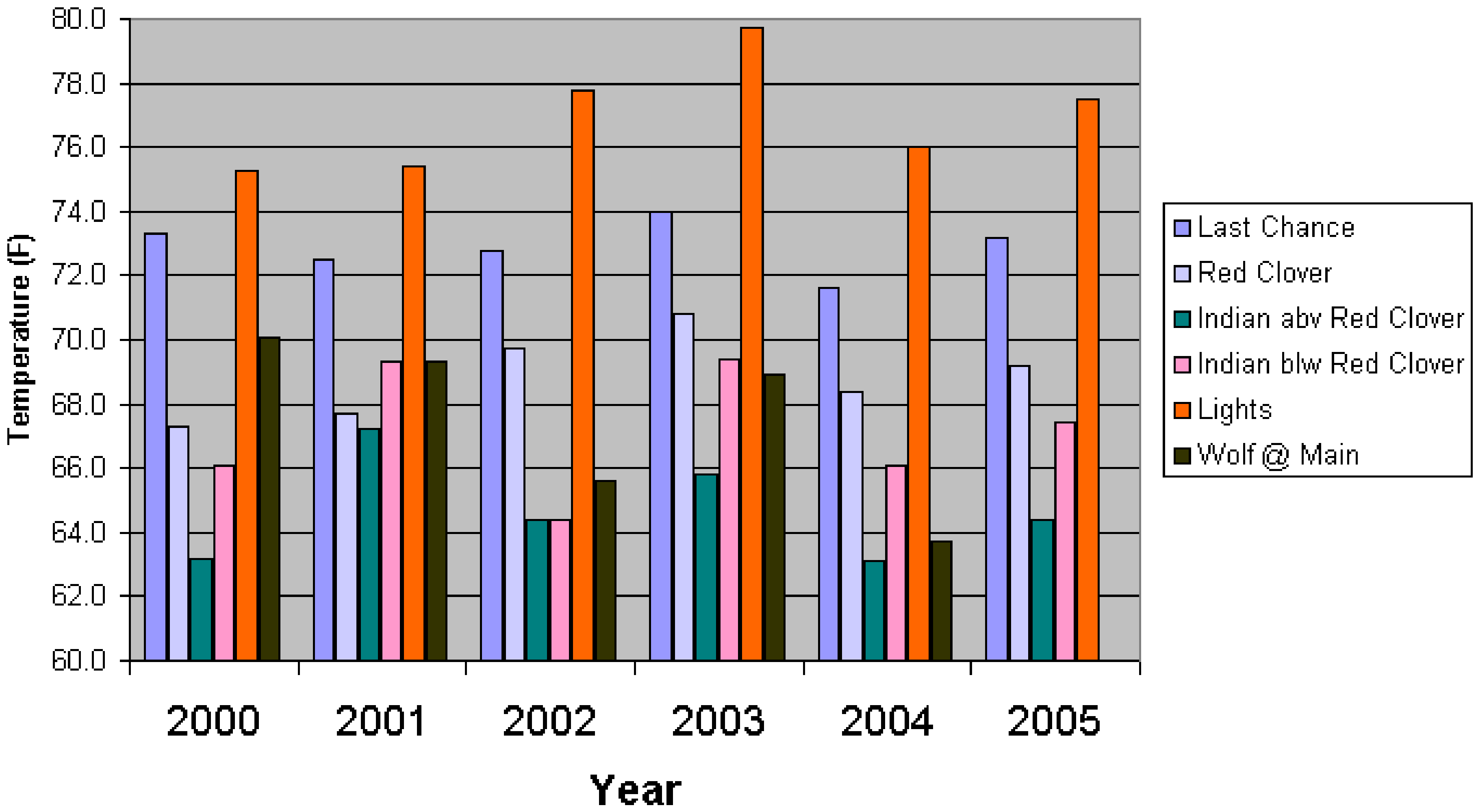


Figure 14. Max Daily Water Temperatures
90.0
85.0
80.0
75.0
70.0
65.0
60.0
Temperature (F)
2000
2001
2002
2003
2004
2005
Year
Last Chance
Red Clover
Indian abv Red Clover
Indian blw Red Clover
Lights
Wolf @ Main

Figure 15. Max Weekly Average Water Temperatures



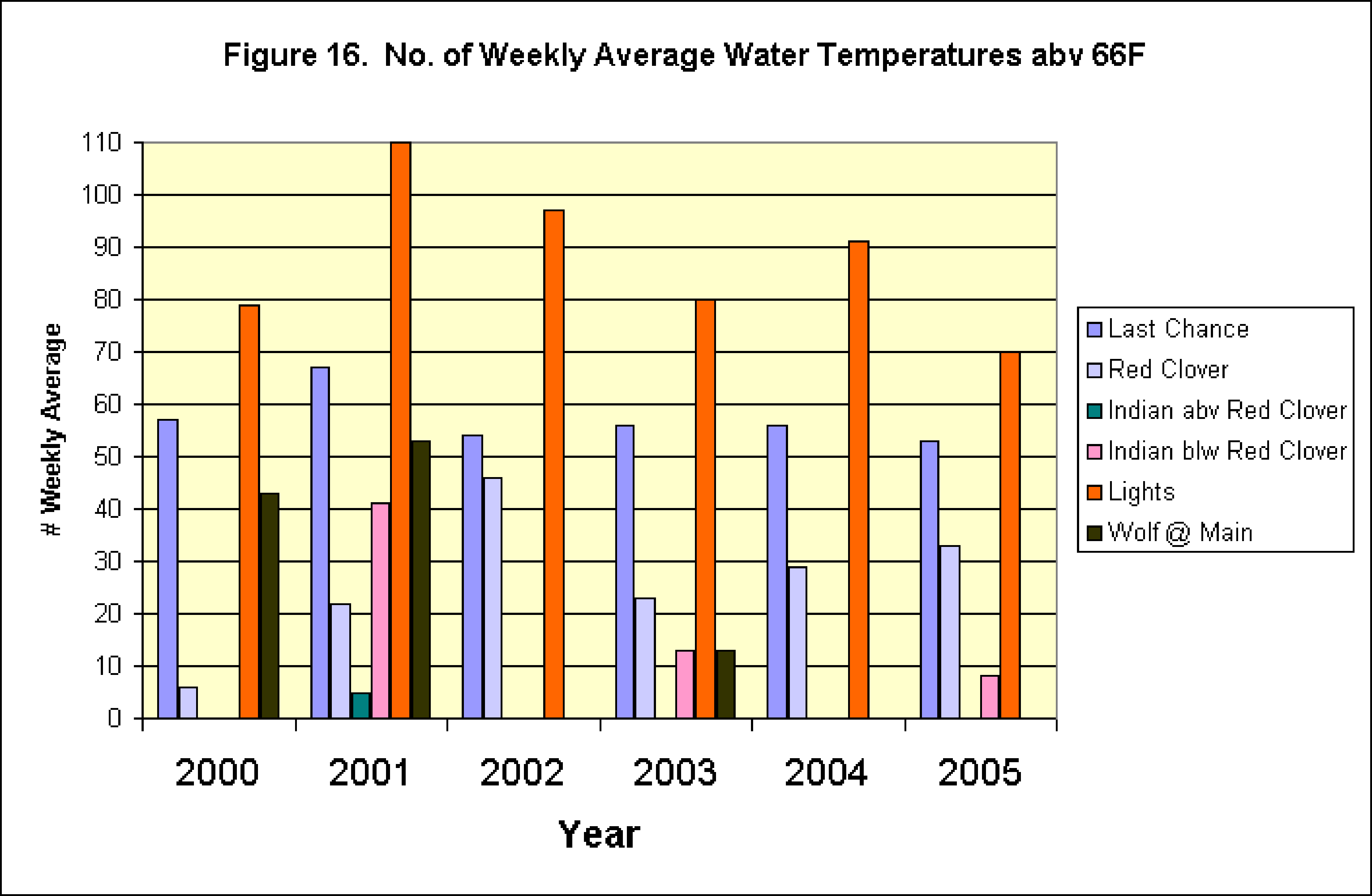


Figure 16. No. of Weekly Average Water Temperatures abv 66F
Weekly Average
0
10
20
30
40
50
60
70
80
90
100
110
2000
2001
2002
2003
2004
2005
Year
Last Chance
Red Clover
Indian abv Red Clover
Indian blw Red Clover
Lights
Wolf @ Main

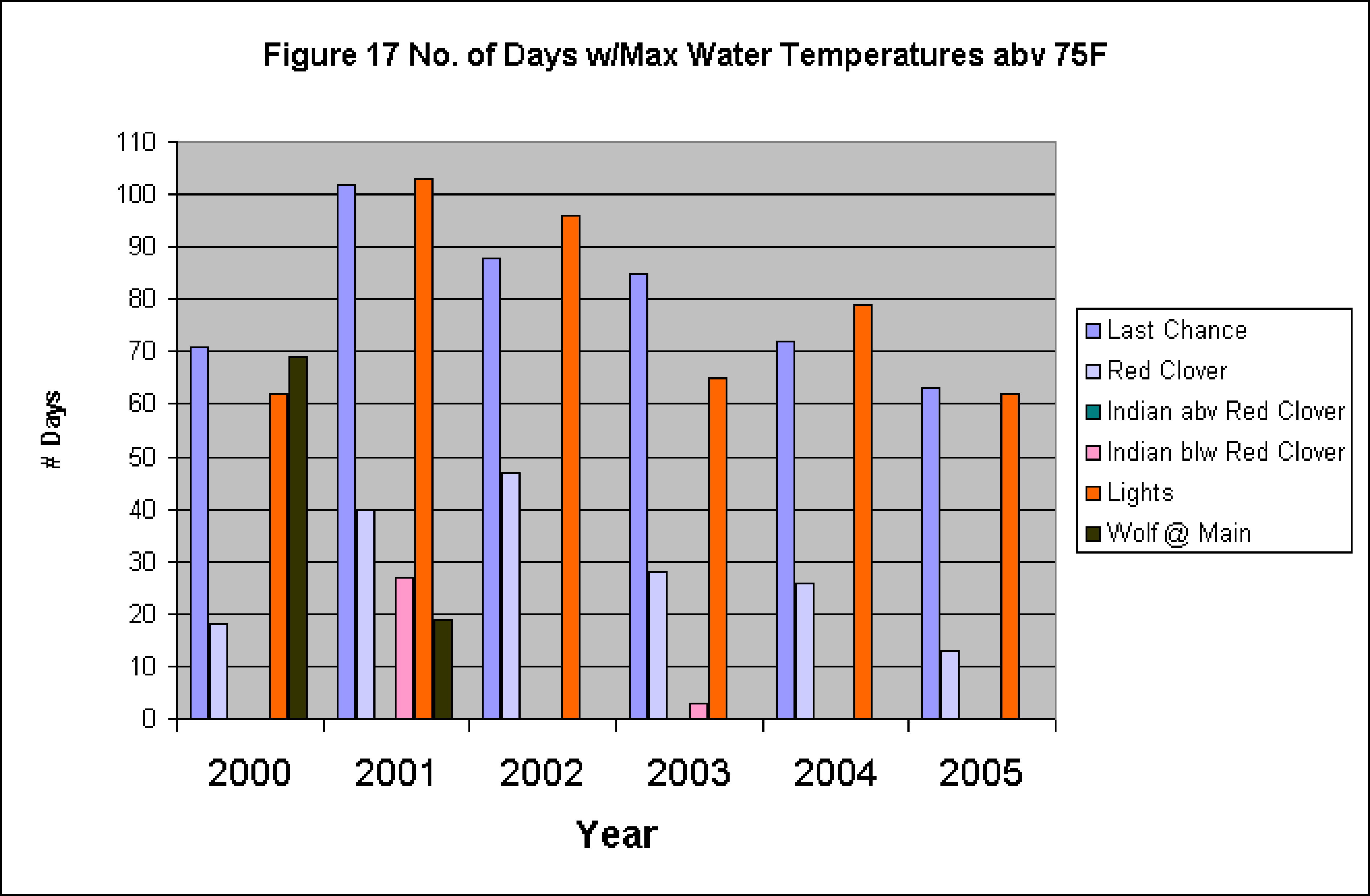


Figure 17 No. of Days w/Max Water Temperatures abv 75F
Days
110
100
90
80
70
60
50
40
30
20
10
0
2000
2001
2002
2003
2004
2005
Year
Last Chance
Red Clover
Indian abv Red Clover
Indian blw Red Clover
Lights
Wolf @ Main

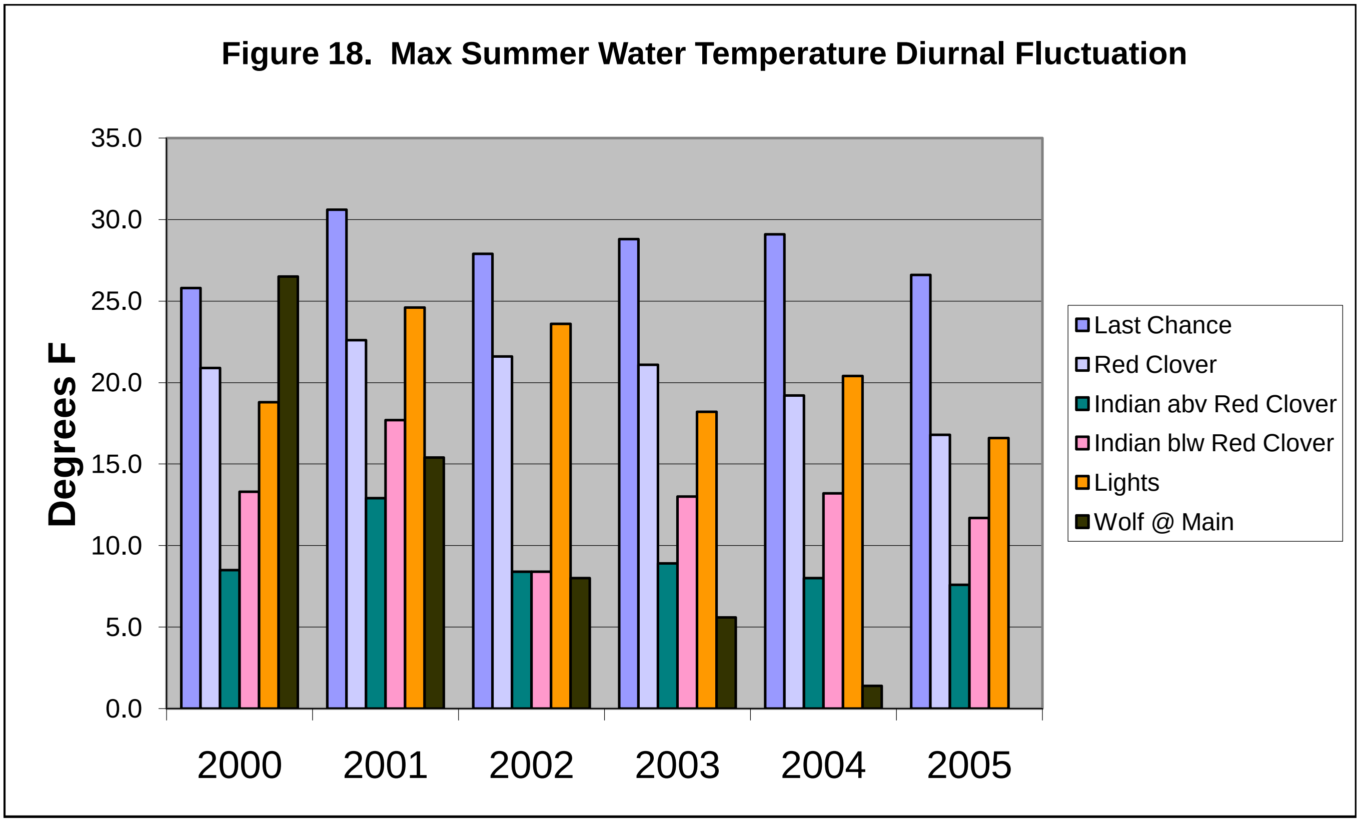


Figure 18. Max Summer Water Temperature Diurnal Fluctuation
Degrees F
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2000
2001
2002
2003
2004
2005
Last Chance
Red Clover
Indian abv Red Clover
Indian blw Red Clover
Lights
Wolf @ Main

Figure 19. Weekly Average Minimum Flow 2000-2005 all sites