UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Turlock Irrigation District	)	
	)	
and	)	Project No. 2299
	)	
Modesto Irrigation District	)	

2008 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2008-8

Review of 2008 Summer Flow Operation

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and

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Introduction

Dry Year Summer Flow Requirement

The Don Pedro Project Article 37 summer minimum flow requirement period at La Grange typically extends from about 01 June to 30 September. That requirement was increased in 1996 to range from 50-250 cfs, with 50 or 75 cfs being in drier year types, depending on hydrologic conditions. The summer flow amount in dry years may be augmented by other water allocated from the total required annual volume. For example, the dry years of 2001-2004 and 2007, have had summer requirements, including augmented flows, ranging from 75-95 cfs,, with the exception of the wetter 2003 conditions discussed below. The Districts' also normally release a somewhat higher flow ("buffer flow") than in the schedule to help ensure minimum requirements are met. This is due to the practice of USGS in sometimes later reporting lesser values than were indicated during real-time operation. The "fish flow year" normally runs from 15 April – 14 April and the schedule amounts are determined by license provisions based on the San Joaquin Basin Index (Index) runoff indicator. In drier years the annual flow volume is based on forecasted amounts until August at the conclusion of the April-July runoff period used in the Index. As a result there can be considerable changes in forecasted volumes from early April until the start of the summer flow period.

2003 Variable Flow Operation

While most dry years since 1996 had their average runoff forecasts become lower after early April, there was a substantial increase in 2003 that resulted in allocations much greater than 75 cfs that summer. That level, initially set at 180 cfs, was changed by later agreement to approximate an average of 205 cfs from 25 June to 30 September using a variable flow for the first time. That operation employed a daily targeted (not minimum) flow of 195 cfs, except that 235 cfs was targeted under specific high forecasted air temperature (AT) criteria (TID/MID 2004). The variable operation was intended to provide relatively cooler instream conditions during hot spells than would otherwise occur at a constant flow release, while using a similar total water volume in the period.

2007 and 2008 Summer Requirements

The 2007 and 2008 Fish Flow Years were very dry and were the first years since 1996 that had an Index so low that the 50 cfs base flow requirement was applicable.

In 2007 there was some augmented water scheduled from the required annual volume, resulting in a total minimum summer flow requirement of 95 cfs through 10 September and 76 cfs during the remainder of that month. Daily average flows later reported by USGS ranged from about

100-120 cfs during the high flow period and 76-88 cfs during the lower flow period in September.

The 2008 hydrologic conditions became much drier after the April 1 runoff forecast, resulting in a lower forecast by late May. As a result, following the allocation of water in the spring pulse flow during April-May, no water was then available in the 2008-2009 Fish Flow Year annual requirement to augment summer flows in the schedule without reducing base flows elsewhere in the remaining part of the fish flow year.

Purpose of 2008 Summer Flow Operation

The minimum required flow schedule transitioned from 150 cfs to 50 cfs during 30 May to 02 June. However, there was interest by Tuolumne River water managers in maintaining instream conditions (e.g. wetted area, habitat availability, WT) more similar to those present in other recent dry years during which minimum required flow schedules had ranged from 75-95 cfs (not including buffer flows). As actual releases were reduced toward 80 cfs in early June, a decision was made to target an average 100 cfs (using realtime values) starting June 10 through September. There was also interest in again attempting to adaptively manage flow operations to provide more thermal benefit than might be provided with a steady flow. The operation was refined starting June 12 to use an approximate 20-cfs range between high and low flow periods to account for changing AT conditions, similar in concept to the 2003 operation.

2008 Criteria

- The lower flow target (not minimum) applied on days when the National Weather Service (NWS) forecast for Modesto maximum AT was 97 degrees or lower
- The higher flow target (not minimum) applied on days when the NWS forecast for Modesto maximum AT was 98 degrees or higher
- Average flow for the period of June 10-September 30 was to be about 100 cfs
- The net difference of low to high flow targets was about 20 cfs as operationally feasible
- NWS 6 AM daily forecast for maximum AT at Modesto was used to establish the daily flow target – this was assumed to be more accurate than using a prior day forecast
- The "target flow day" at the USGS La Grange flow gage ran from morning to morning

2008 Operation and Implementation

The operation went reasonably smoothly, although several factors were identified that can affect operations or instream conditions:

- mechanical constraints in making flow releases limit the ability to precisely operate at a specific flow target
- flow changes take time to affect conditions further downstream, so earlier same-day changes were likely more effective on a real-time basis

- nighttime low ATs (as measured at Turlock) were considerably hotter than average as compared to daytime maximum ATs in 2008
- extreme heat conditions of greater than 104 F occurred in three multi-day periods
- the official weather forecast location of Modesto was used as a predictor for the river reach many miles upstream where thermal conditions may not be relatively consistent with Modesto
- same-day temperature forecasts can be off several degrees, sometimes resulting in flow targets inconsistent with realtime conditions
- flow releases relative to the targets and flow measurements by USGS are imprecise due to the difficulties of a dynamic operational environment
- transition days to lower or higher targets tend to have intermediate daily flow averages due to the timing of flow changes
- hotter periods and higher thermal input mainly occur in mid-June through August based on historical patterns; the lower flow target was maintained during the last two 98 F forecast days in September as the Modesto WT conditions were much lower than in earlier periods

The only realtime WT data is available at the USGS Modesto gage (RM 16.2), a location too far downstream to have WT affected by low flow operational changes. Other WT data used here was available following manual download of thermographs.

Data/Results

The thermograph data for the entire period was posted to the TRTAC website and notification of their availability was made on 16 October 2008.

The graphs are as follows:

- forecasted and actual maximum AT over the 113-day period of 10 June to 30 September; most extreme heat wave was July 7-10 with peak AT of 109 F
- the deviation of actual ATs from forecasts – these ranged from +6 to -5 F with an average deviation of zero; 13 days would have had a different target flow with a perfect forecast
- daily average flow, daily maximum AT, and the higher flow target days (34 of 113 days, or 30%); a total of 7 multi-day high flow target periods occurred and ranged from 4-6 days in duration; the June 10 – September 30 real-time flow average was 100 cfs, ranging from 88-122 cfs (excepting 30 September in transition to higher 01 October flow)
- daily average WT at 9 stations from La Grange gage at River Mile (RM) 51.8 down to Modesto gage (RM 16.2) with higher flow target days shown
- dynamics of flow, maximum AT, and average WT at RM 45.5, 42.9, 39.6, and 16.2 (using higher WT axis range) on four graphs

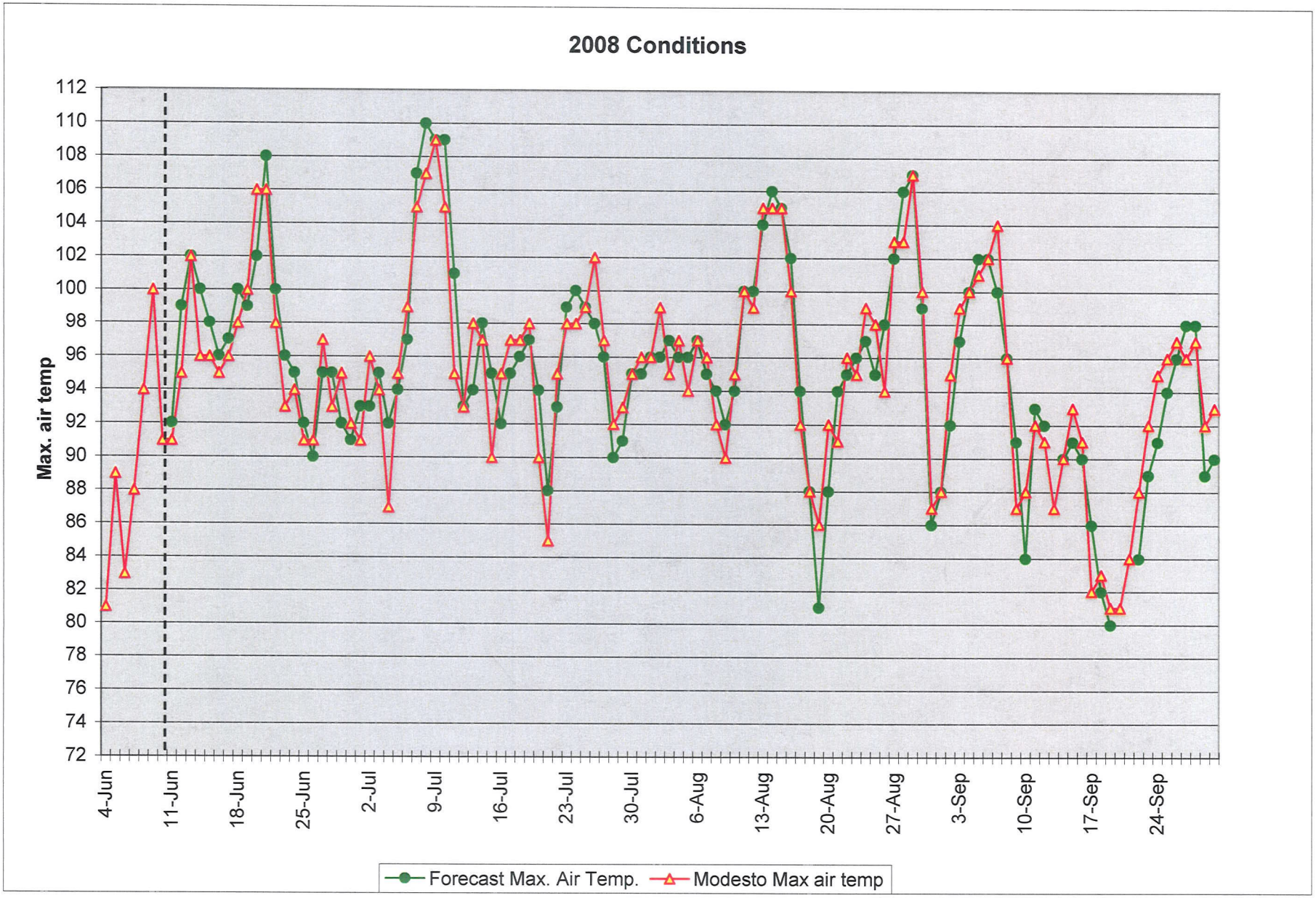
Some other general observations are:

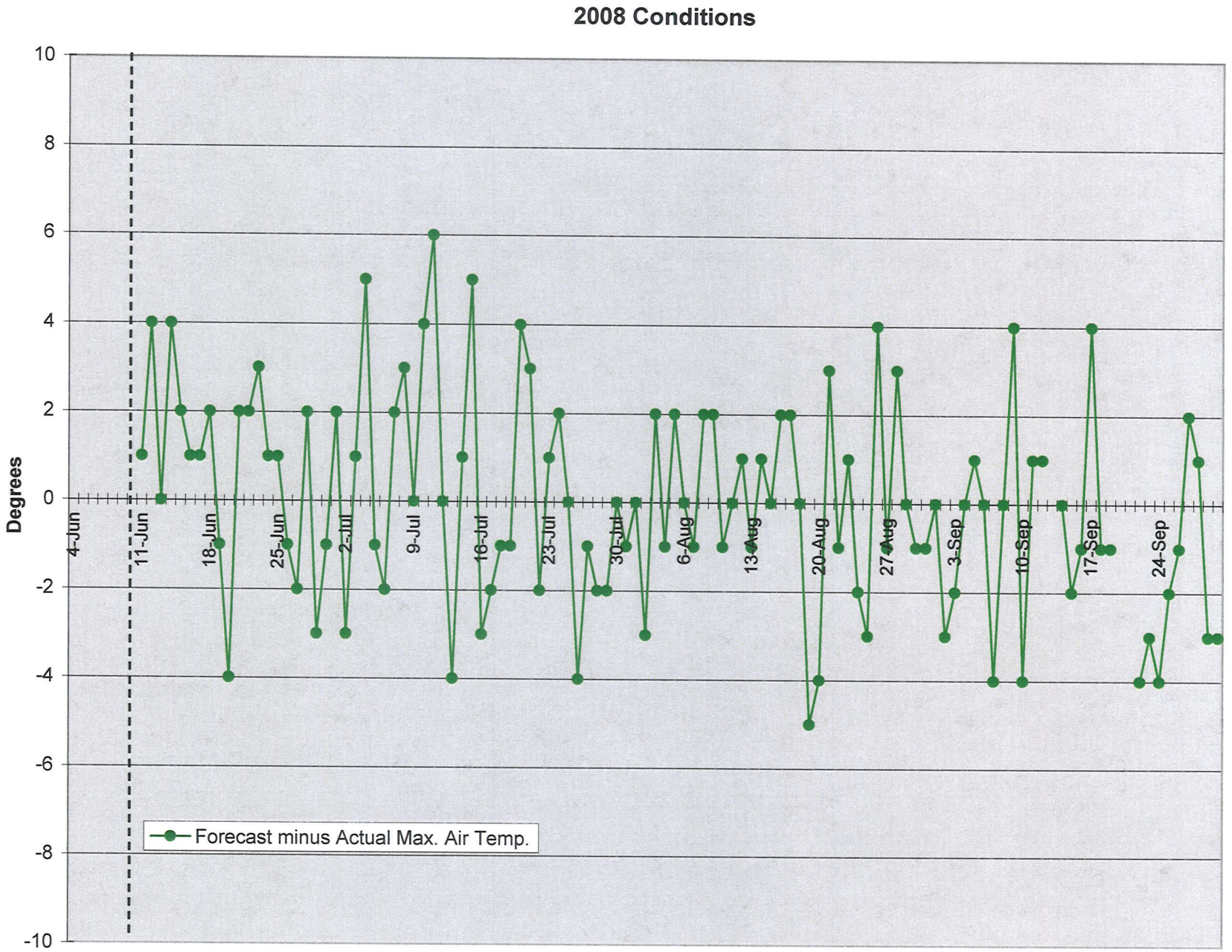
- WT increased in a downstream direction as typical and through about RM 23.6
- Peak WTs were mainly evident in the early July extreme heat wave from RM 42.9 downstream

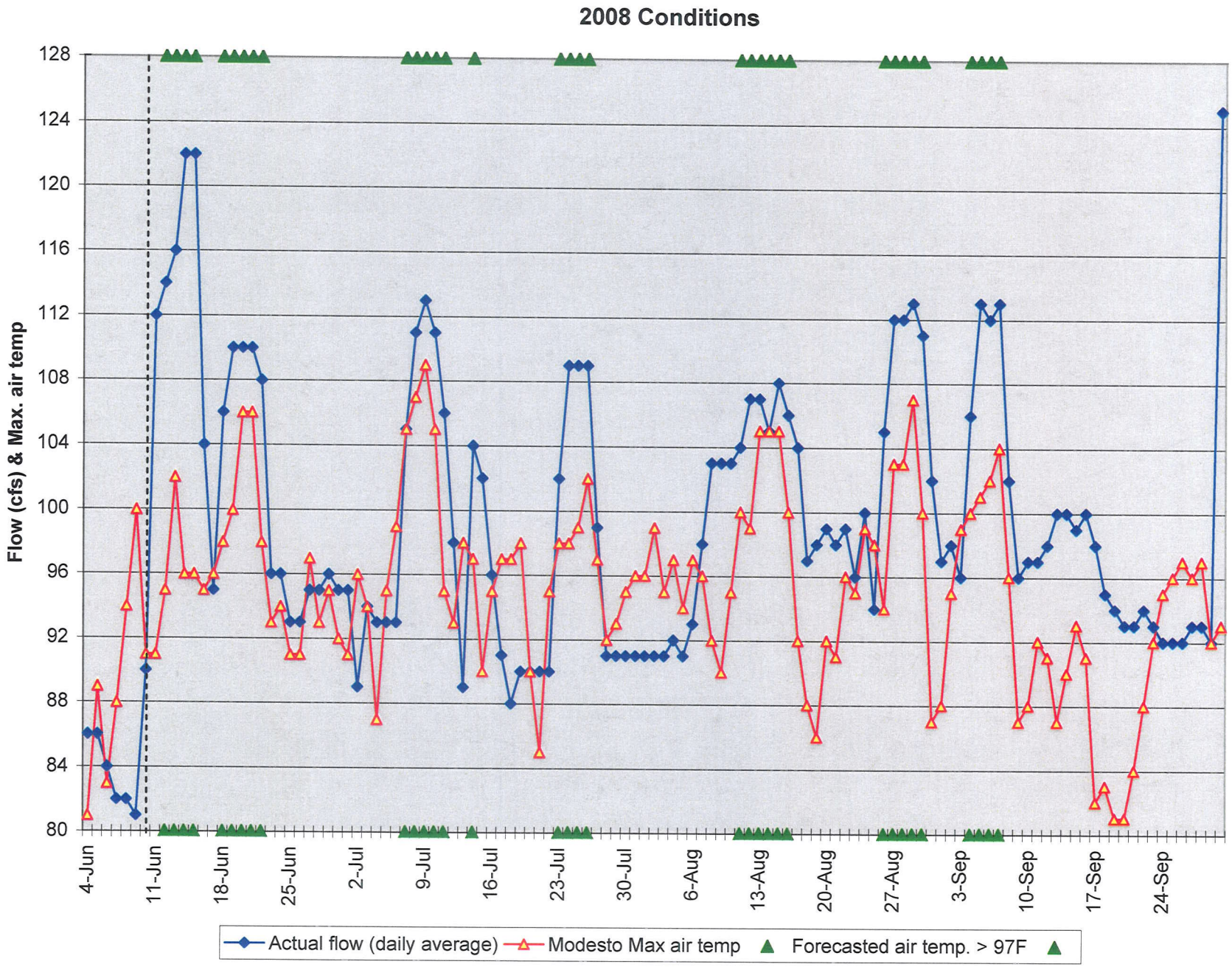
- Overall WT variation (more than 4 F range) was more evident from RM 45.5 downstream
- Reduced WTs from those of mid-June through August were generally present in most of September from RM 49 downstream, even though the upstream temperature at RM 51.8 was slightly higher

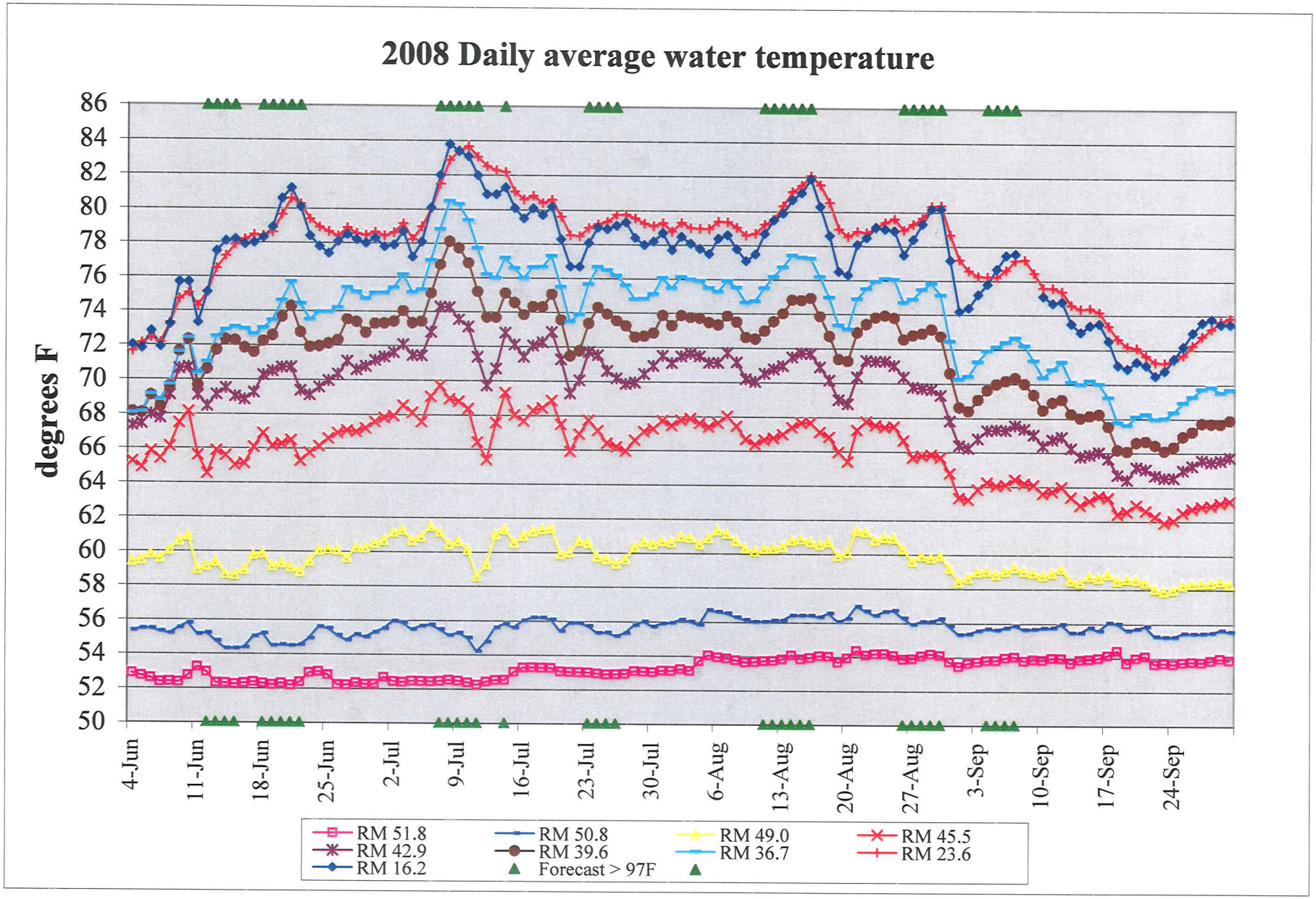
Reference

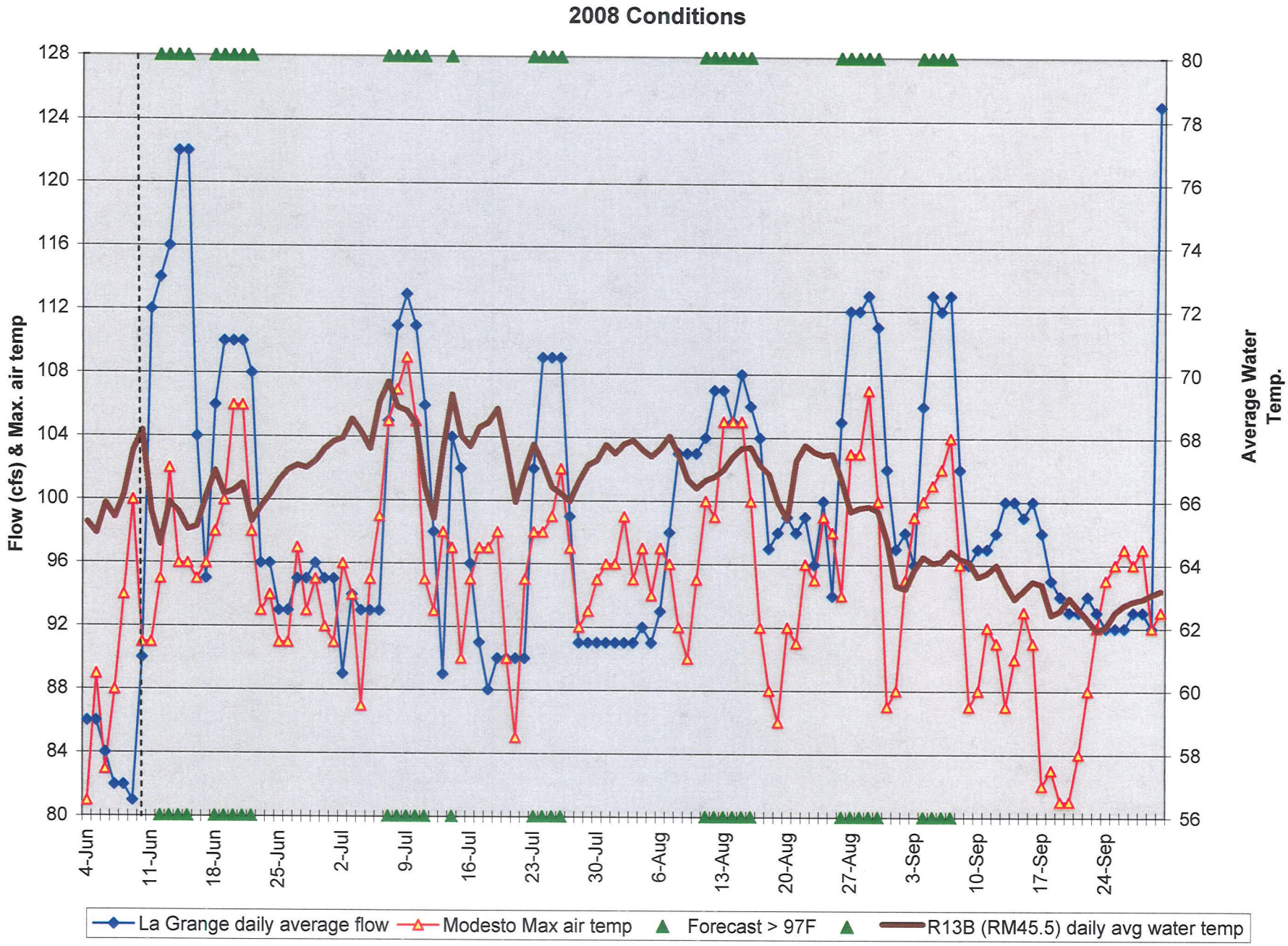
TID/MID. 2004. Review of 2003 summer flow operation. Report 2003-4 *In* Annual Report of Turlock Irrigation District and Modesto Irrigation District Pursuant to Article 58 of the License for the Don Pedro Project, No. 2299. Prepared by T. Ford and S. Kirihara.

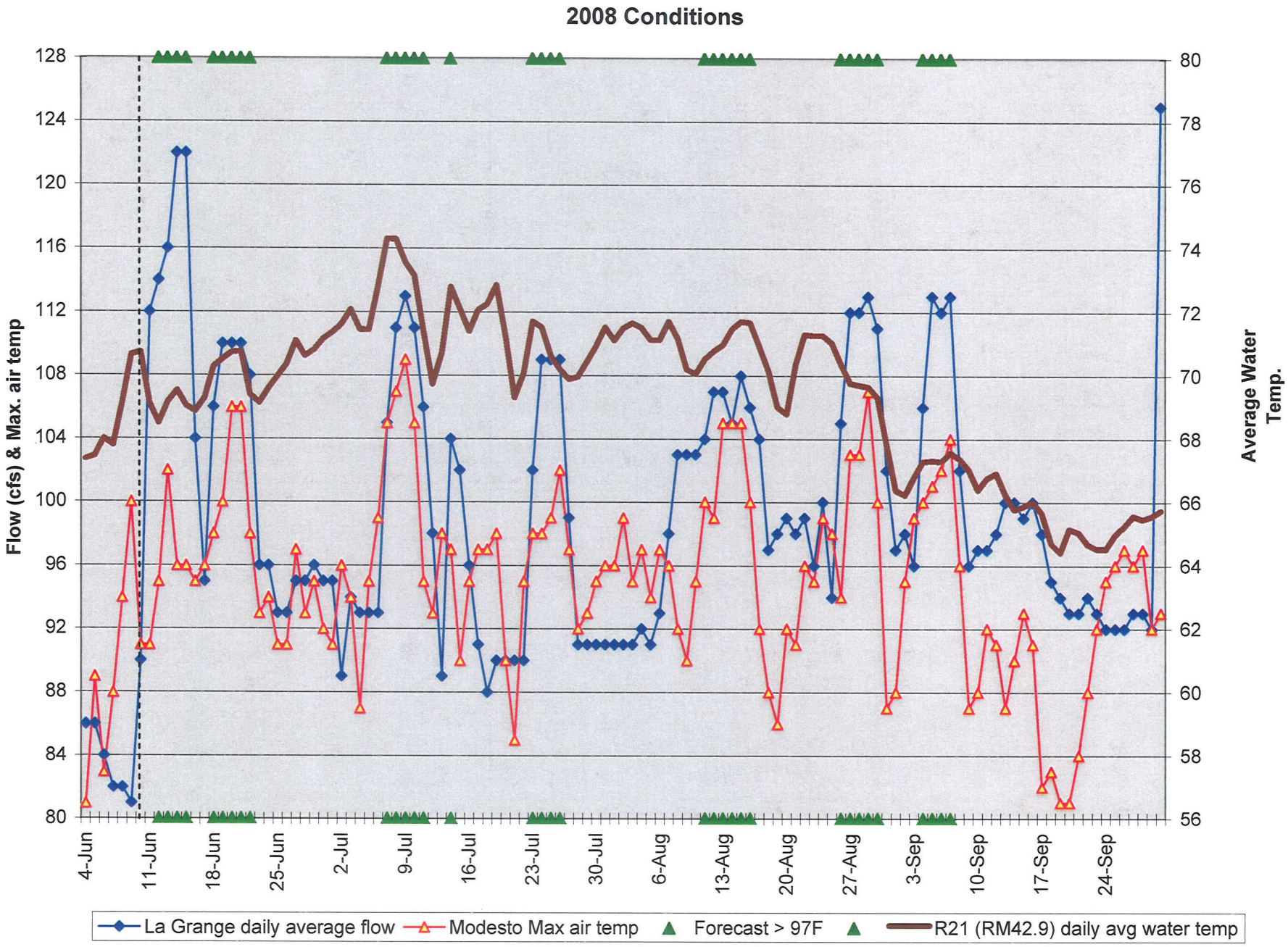

2008 Conditions
Max. air temp
112
110
108
106
104
102
100
98
96
94
92
90
88
86
84
82
80
78
76
74
72
4-Jun
11-Jun
18-Jun
25-Jun
2-Jul
9-Jul
16-Jul
23-Jul
30-Jul
6-Aug
13-Aug
20-Aug
27-Aug
3-Sep
10-Sep
17-Sep
24-Sep
Forecast Max. Air Temp.
Modesto Max air temp

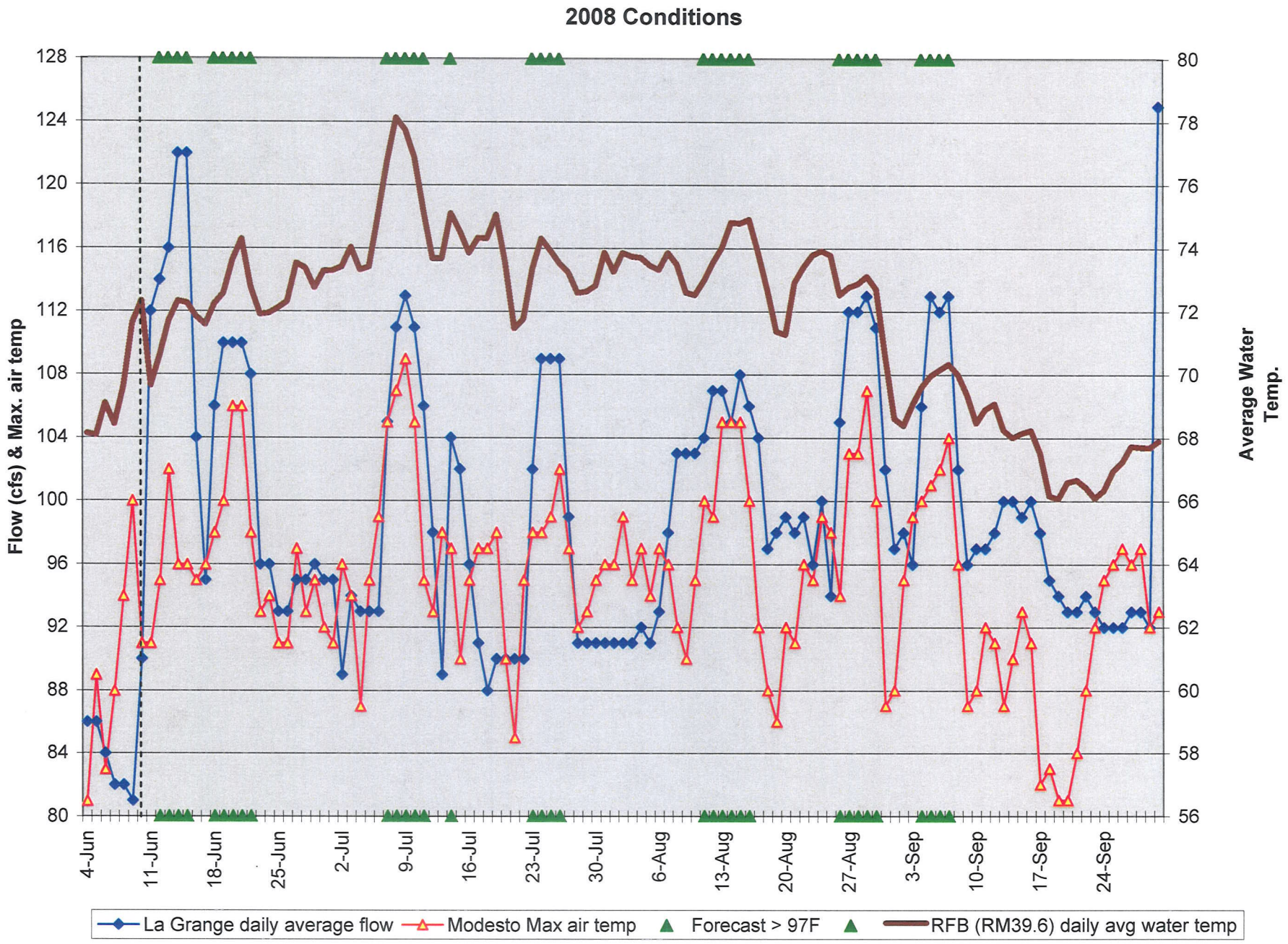

2008 Conditions
Degrees
10
8
6
4
2
0
-2
-4
-6
-8
-10
4-Jun
11-Jun
18-Jun
25-Jun
2-Jul
9-Jul
16-Jul
23-Jul
30-Jul
6-Aug
13-Aug
20-Aug
27-Aug
3-Sep
10-Sep
17-Sep
24-Sep
Forecast minus Actual Max. Air Temp.

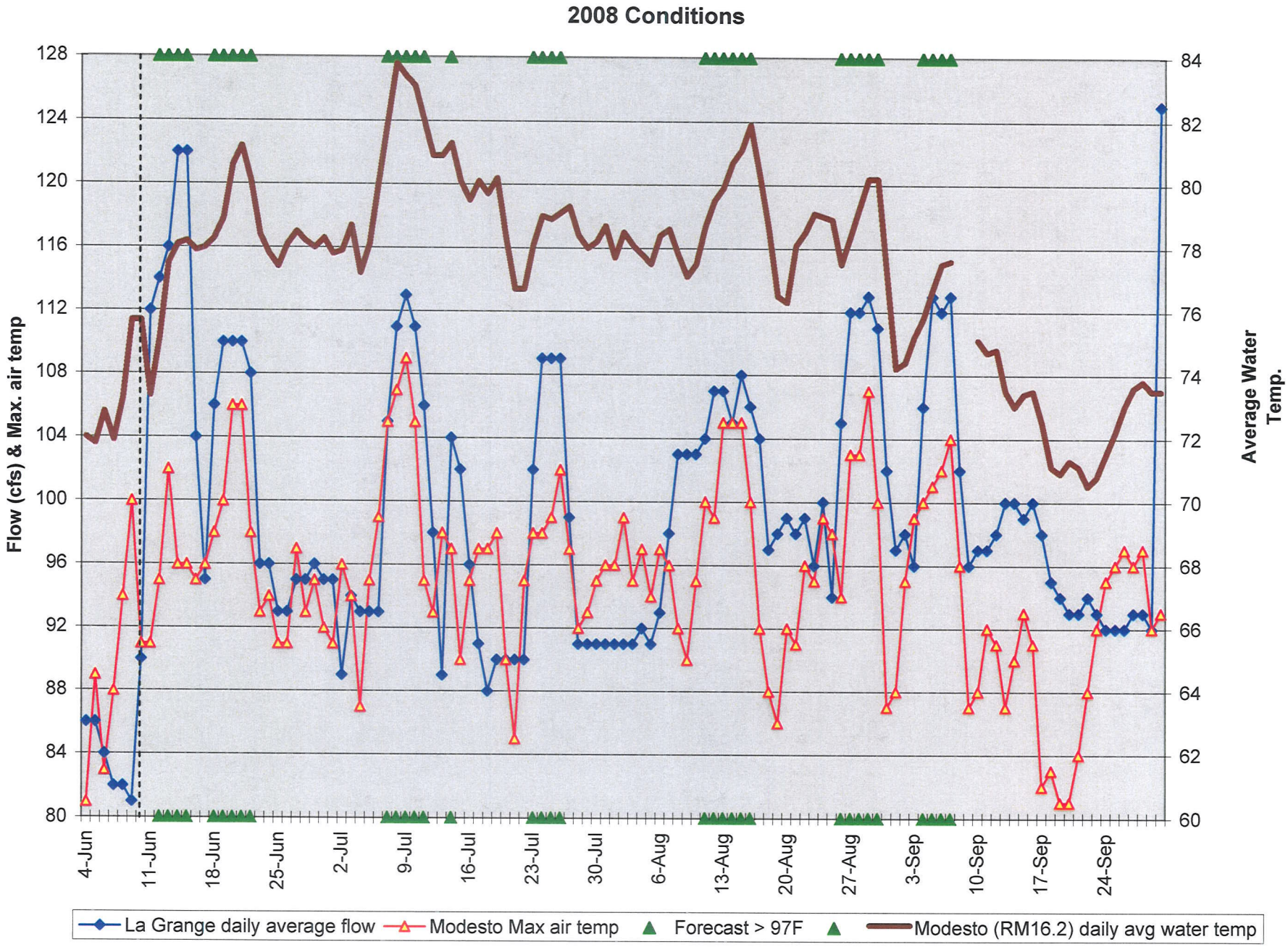

2008 Conditions
Flow (cfs) & Max. air temp
128
124
120
116
112
108
104
100
96
92
88
84
80
4-Jun
11-Jun
18-Jun
25-Jun
2-Jul
9-Jul
16-Jul
23-Jul
30-Jul
6-Aug
13-Aug
20-Aug
27-Aug
3-Sep
10-Sep
17-Sep
24-Sep
Actual flow (daily average)
Modesto Max air temp
Forecasted air temp. > 97F


2008 Daily average water temperature
degrees F
86
84
82
80
78
76
74
72
70
68
66
64
62
60
58
56
54
52
50
4-Jun
11-Jun
18-Jun
25-Jun
2-Jul
9-Jul
16-Jul
23-Jul
30-Jul
6-Aug
13-Aug
20-Aug
27-Aug
3-Sep
10-Sep
17-Sep
24-Sep
RM 51.8
RM 50.8
RM 49.0
RM 45.5
RM 42.9
RM 39.6
RM 36.7
RM 23.6
RM 16.2
Forecast > 97F


2008 Conditions
Flow (cfs) & Max. air temp
Average Water Temp.
128
124
120
116
112
108
104
100
96
92
88
84
80
80
78
76
74
72
70
68
66
64
62
60
58
56
4-Jun
11-Jun
18-Jun
25-Jun
2-Jul
9-Jul
16-Jul
23-Jul
30-Jul
6-Aug
13-Aug
20-Aug
27-Aug
3-Sep
10-Sep
17-Sep
24-Sep
La Grange daily average flow
Modesto Max air temp
Forecast > 97F
R13B (RM45.5) daily avg water temp


2008 Conditions
Flow (cfs) & Max. air temp
Average Water Temp.
128
124
120
116
112
108
104
100
96
92
88
84
80
80
78
76
74
72
70
68
66
64
62
60
58
56
4-Jun
11-Jun
18-Jun
25-Jun
2-Jul
9-Jul
16-Jul
23-Jul
30-Jul
6-Aug
13-Aug
20-Aug
27-Aug
3-Sep
10-Sep
17-Sep
24-Sep
La Grange daily average flow
Modesto Max air temp
Forecast > 97F
R21 (RM42.9) daily avg water temp


2008 Conditions
Flow (cfs) & Max. air temp
Average Water Temp.
128
124
120
116
112
108
104
100
96
92
88
84
80
80
78
76
74
72
70
68
66
64
62
60
58
56
4-Jun
11-Jun
18-Jun
25-Jun
2-Jul
9-Jul
16-Jul
23-Jul
30-Jul
6-Aug
13-Aug
20-Aug
27-Aug
3-Sep
10-Sep
17-Sep
24-Sep
La Grange daily average flow
Modesto Max air temp
Forecast > 97F
RFB (RM39.6) daily avg water temp


2008 Conditions
Flow (cfs) & Max. air temp
Average Water Temp.
128
124
120
116
112
108
104
100
96
92
88
84
80
84
82
80
78
76
74
72
70
68
66
64
62
60
4-Jun
11-Jun
18-Jun
25-Jun
2-Jul
9-Jul
16-Jul
23-Jul
30-Jul
6-Aug
13-Aug
20-Aug
27-Aug
3-Sep
10-Sep
17-Sep
24-Sep
La Grange daily average flow
Modesto Max air temp
Forecast > 97F
Modesto (RM16.2) daily avg water temp