Stanislaus Temperature Modeling
2016 Proposed Operations
Water Allocation Schedule – March 20, 2016

General:

The objective of this work is to assess, using the HEC-5Q Model, the expected temperature conditions at discrete points along the Stanislaus River, given the most recent projections of inflow to New Melones Reservoir, proposed instream flow requirements and various alternatives for OID/SSJID/SEWD diversions from March 20, 2016 through December 31, 2016.

Tasks:

1. Set up the model to run a year with observed and synthesized data similar to the 2015 analysis:
   a. Extend the meteorological inputs (April 2015 thru present). Use last year's (2015) conditions going forward.
   b. Extend the hydrologic inputs through present based on available data.
   c. Consider two alternatives for New Melones Unimpaired Flow (UF) conditions in the water year 2016:
      - Based on the 90% forecast (New Melones inflow ~ 926 TAF)
      - Based on the 75% forecast (New Melones inflow ~ 996 TAF).
   d. Disaggregate the estimated monthly New Melones inflow to daily using inflow records for similar monthly inflows (monthly data provided in Figure 1 & 2 below).
   e. Disaggregate the estimated monthly diversion and Goodwin flows incorporating pulse flow when appropriate (monthly data provided in Figure 1 & 2 below).
   f. Prime the model by setting New Melones and Tulloch to the November 2015 temperature profiles and to the most recent profiles taken in March 2016 (see Task 2).
2. Conduct field measurements for New Melones and Tulloch temperature profiles on March 9, 2016.
3. Incorporate representation of Tulloch's third unit in the model (based on specifications provided by Tri-Dam).
4. Perform model validation by running the model from Jan 1, 2015 to March 8, 2016 and comparing computed temperatures with observed.
5. Perform model simulation, assuming no hydro bypass at New Melones, for the two alternatives by running the model from March 8 to December 31, 2016. Compute the thermal regime downriver.
6. Analyze the results in terms of the expected temperatures (7DADM) at the specified locations along the Stanislaus River from day 1 of the simulation to end-of-year 2016.
7. Prepare a short summary report containing: methodology, assumptions, model verification and results.

System Operation - Projected Hydrology and Assumed Demands						
Based on March 20, 2016 - 90% Forecast						
Beginning	**NM Inflow**	**Goodwin OID/SSJID**	**Goodwin SEWD**	**Total Diversion**	**Goodwin To River**	**Goodwin To River**
	TAF	**TAF**	**TAF**	**TAF**	**CFS**	**TAF**
1-Mar-16	182.0	16.7		16.7	208	12.8
1-Apr-16	44.0	35.0		35.0	200	5.6
15-Apr-16	76.0	41.0		41.0	1908	60.6
1-May-16	80.0	37.0		37.0	1877	55.8
16-May-16	65.0	37.0		37.0	150	4.8
1-Jun-16	82.0	79.0	3.0	82.0	150	8.9
1-Jul-16	40.0	97.0	4.0	101.0	150	9.2
1-Aug-16	44.0	88.0	3.0	91.0	150	9.2
1-Sep-16	37.0	63.0		63.0	150	8.9
1-Oct-16	20.0	0.0		0.0	577	35.5
1-Nov-16	20.0	0.0		0.0	200	11.9
1-Dec-16	20.0	0.0		0.0	200	12.3
Total (Mar-Sep)	650.0	493.7	10.0	503.7		175.8

Figure 1: New Melones Inflow, Diversion and Release Schedule – 90% UF

System Operation - Projected Hydrology and Assumed Demands						
Based on March 20, 2016 - 75% Forecast						
Beginning	**NM Inflow**	**Goodwin OID/SSJID**	**Goodwin SEWD**	**Total Diversion**	**Goodwin To River**	**Goodwin To River**
	TAF	**TAF**	**TAF**	**TAF**	**CFS**	**TAF**
1-Mar-16	182.0	16.7		16.7	208	12.8
1-Apr-16	44.0	35.0		35.0	200	5.6
15-Apr-16	80.0	41.0		41.0	1908	60.6
1-May-16	95.0	37.0		37.0	1877	55.8
16-May-16	81.0	37.0		37.0	150	4.8
1-Jun-16	110.0	79.0	3.0	82.0	150	8.9
1-Jul-16	44.0	97.0	4.0	101.0	150	9.2
1-Aug-16	46.0	88.0	3.0	91.0	150	9.2
1-Sep-16	38.0	63.0		63.0	150	8.9
1-Oct-16	20.0	0.0		0.0	577	35.5
1-Nov-16	20.0	0.0		0.0	200	11.9
1-Dec-16	20.0	0.0		0.0	200	12.3
Total (Mar-Sep)	720.0	493.7	10.0	503.7		175.8

Figure 2: New Melones Inflow, Diversion and Release Schedule – 75% UF

Modeling, Analysis and Findings

1. Model Validation

Model validation was conducted by simulating the operation of the Stanislaus River System with actual hydrological and meteorological data from January 1, 2015 through March 8, 2016 and then comparing computed temperature downriver with observed. It should be emphasized that the HEC-5Q was not recalibrated for the purpose of this study but rather validated. In other words, none of the parameters used in the computation process as currently exist in the model have been modified.

The first measure of validation is how well the model replicates the thermal structure in New Melones and Tulloch in comparison with the most recent temperature profiles taken for these reservoirs.

Temperature profiles for Tulloch and New Melones were taken in May, June and October of 2015. However, in order to ensure that the model starts with the most recent and most accurate thermal structure in the reservoirs when projecting temperatures forward in time, additional profiles were taken on March 9, 2016.

A comparison between the computed and observed temperature profiles in New Melones and Tulloch is shown in Figure 3 and Figure 4 below.

The figures show a good match between computed and observed temperatures, thus concluding that the model performed to par as well as was primed properly for this study.

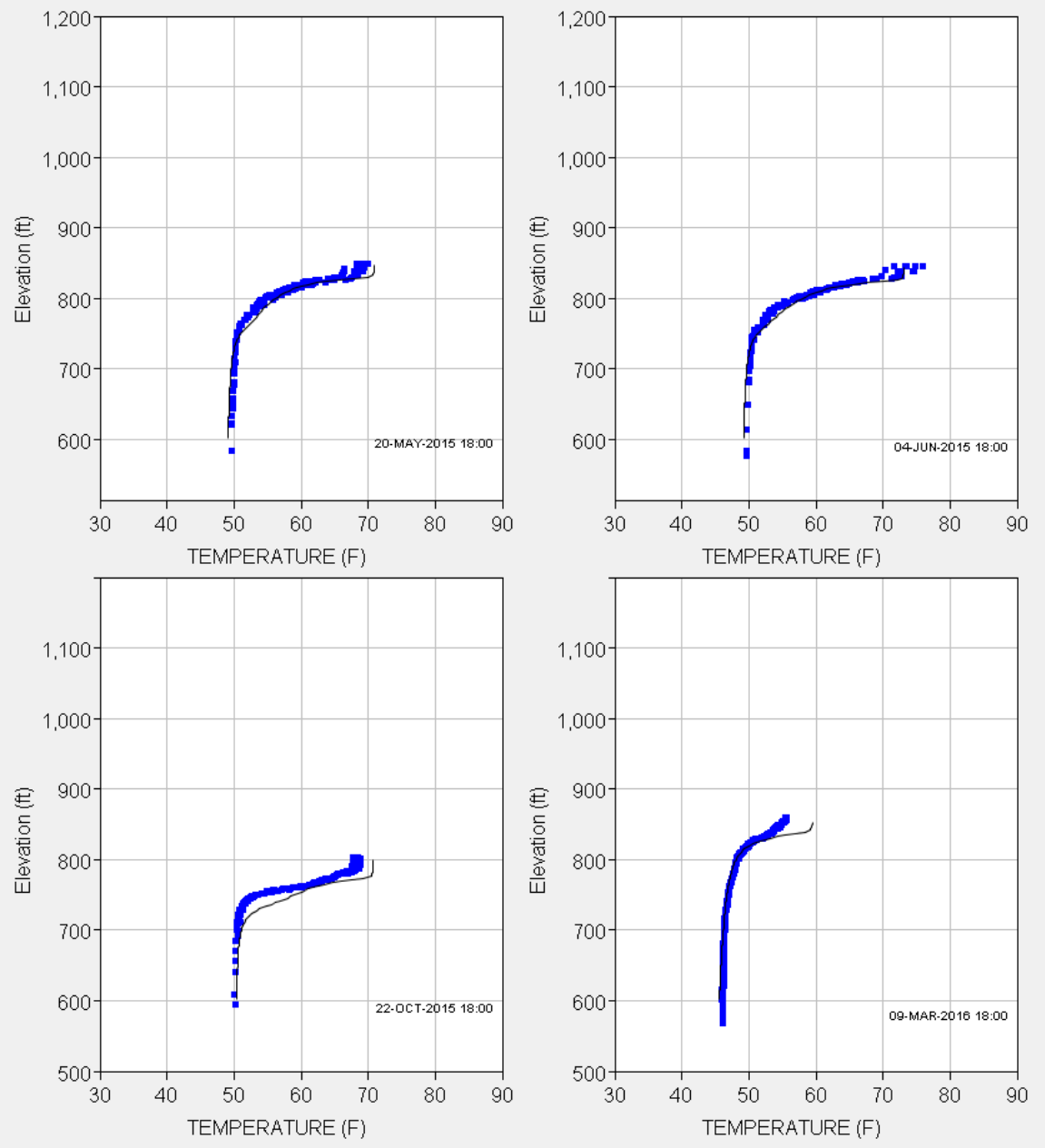

Figure 3: Temperature Profile in New Melones. Computed (line) vs. Observed (squares).

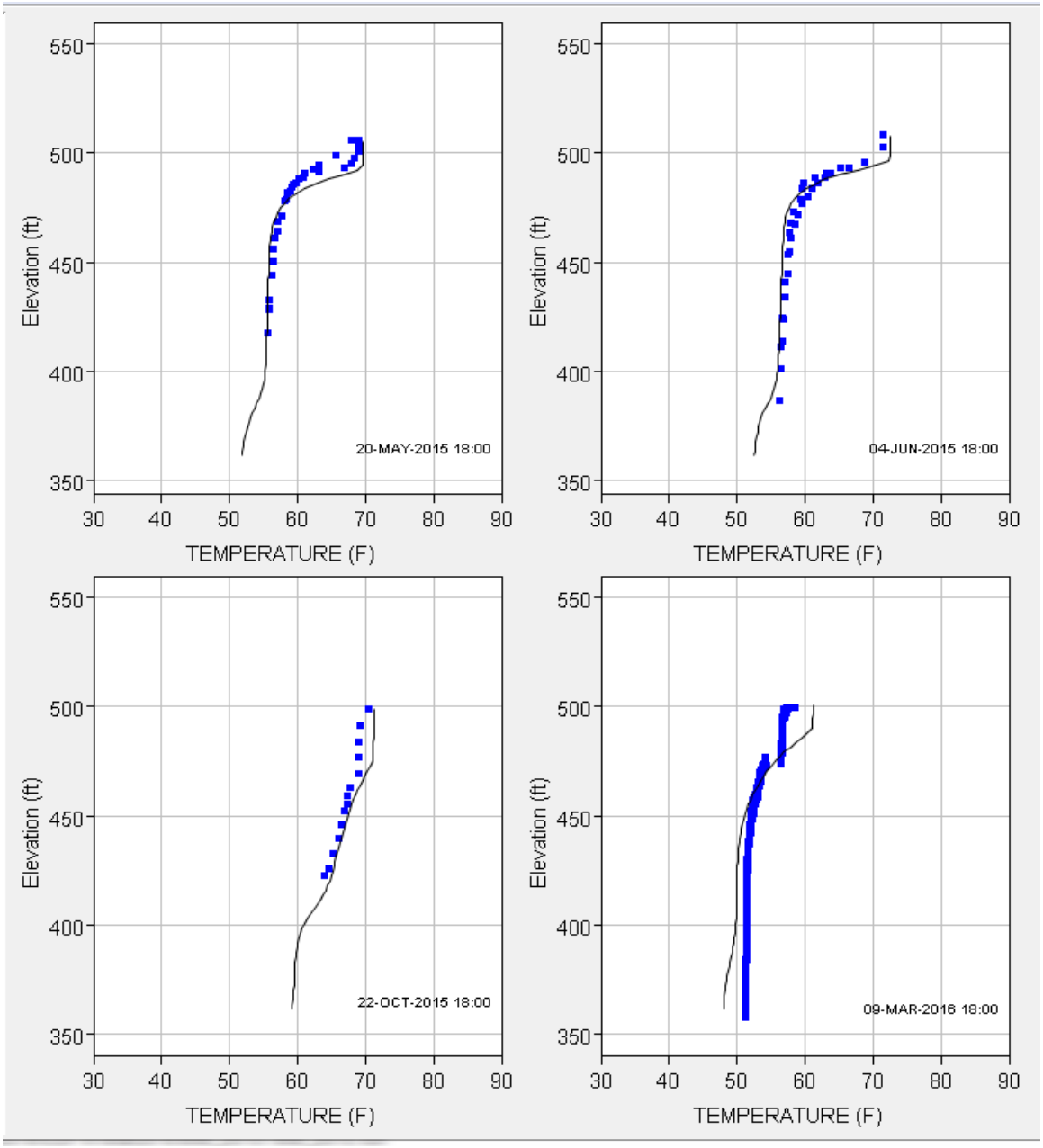

Figure 4: Temperature Profile in Tulloch. Computed (line) vs. Observed (squares).

The second measure of validation is how well the model was able to compute temperature condition downriver for the same time period (i.e., January 1, 2015 to March 8, 2016).

The results are shown in the following three plots, for three locations:

- Goodwin Pool below Tulloch Power Plant
- Below Goodwin Dam
- Below Hwy 120 Bridge (Oakdale)

Here again, the results demonstrate a good match between computed and observed.

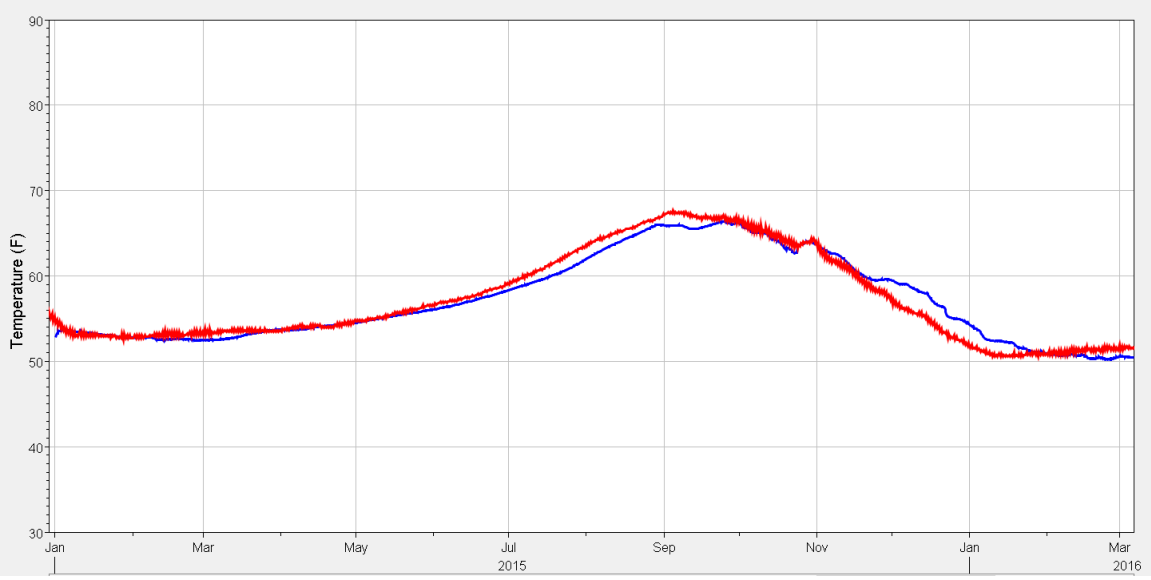

Figure 5: Computed (blue) vs. Observed (red) below Tulloch Power Plant

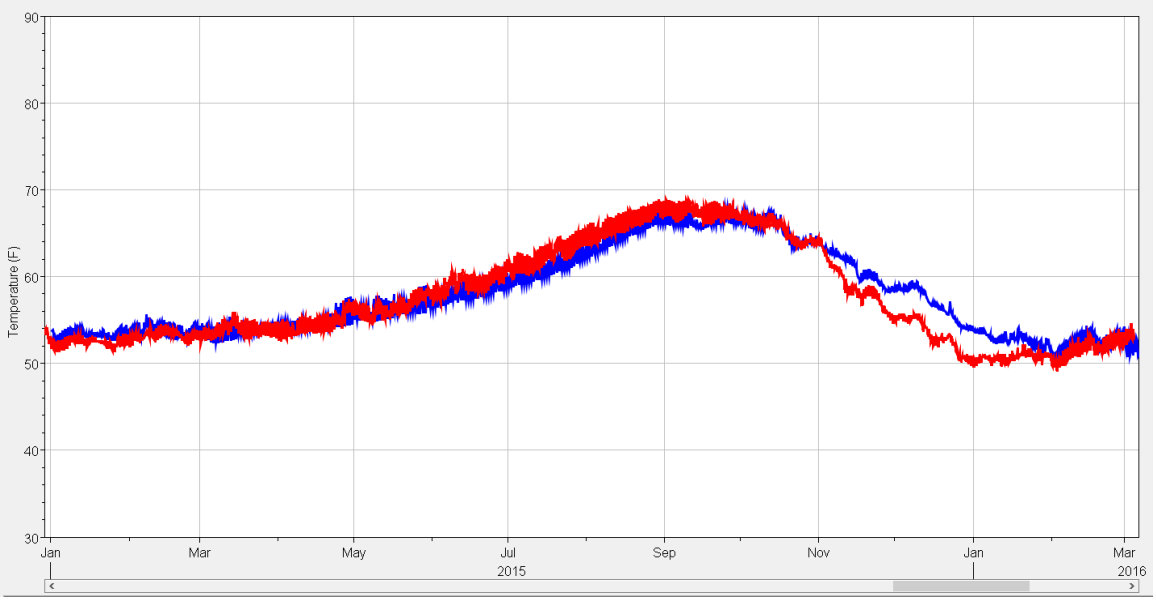

Figure 6: Computed (blue) vs. Observed (red) below Goodwin Dam

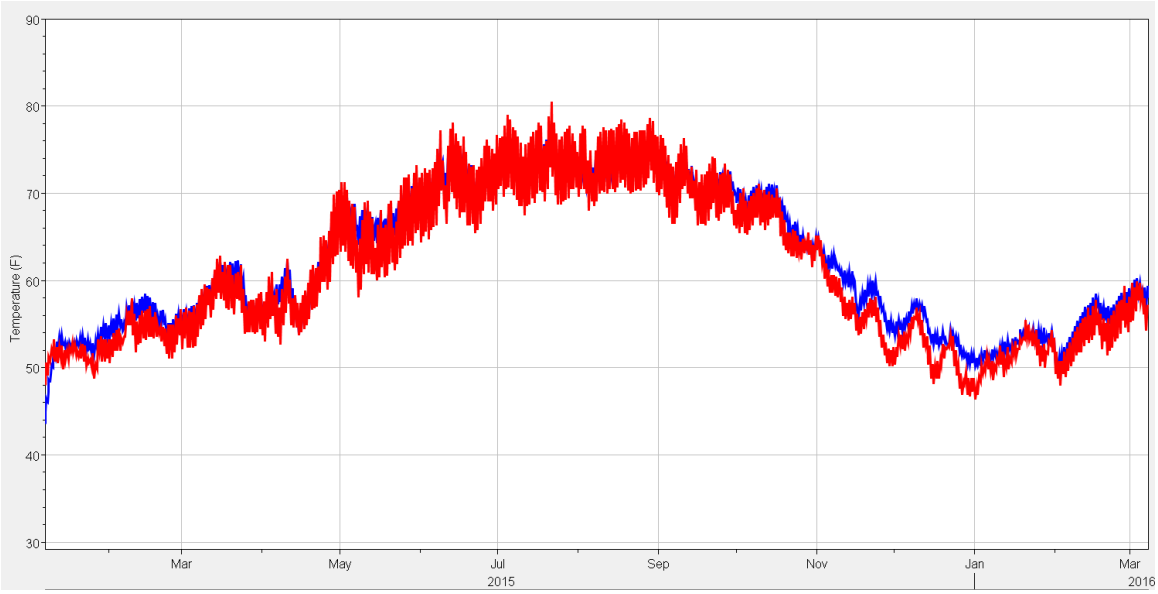

Figure 7: Computed (blue) vs. Observed (red) below Hwy 120 Bridge (Oakdale)

2. Hydrological and Meteorological Data used for Simulation

The pattern of inflow to New Melones for the remainder of this year was based on the pattern of inflow that was observed in 2010. The justification for that is the fact that the level of snowpack that was present in January and February of 2010 and the resulting inflow to New Melones, appear to be similar to the current conditions, as shown in Figure 9 and Figure 9 below. The volume of the inflow in a daily basis was then scaled down to match the monthly estimates for 2016, as specified in Figure 1 and Figure 2 above.

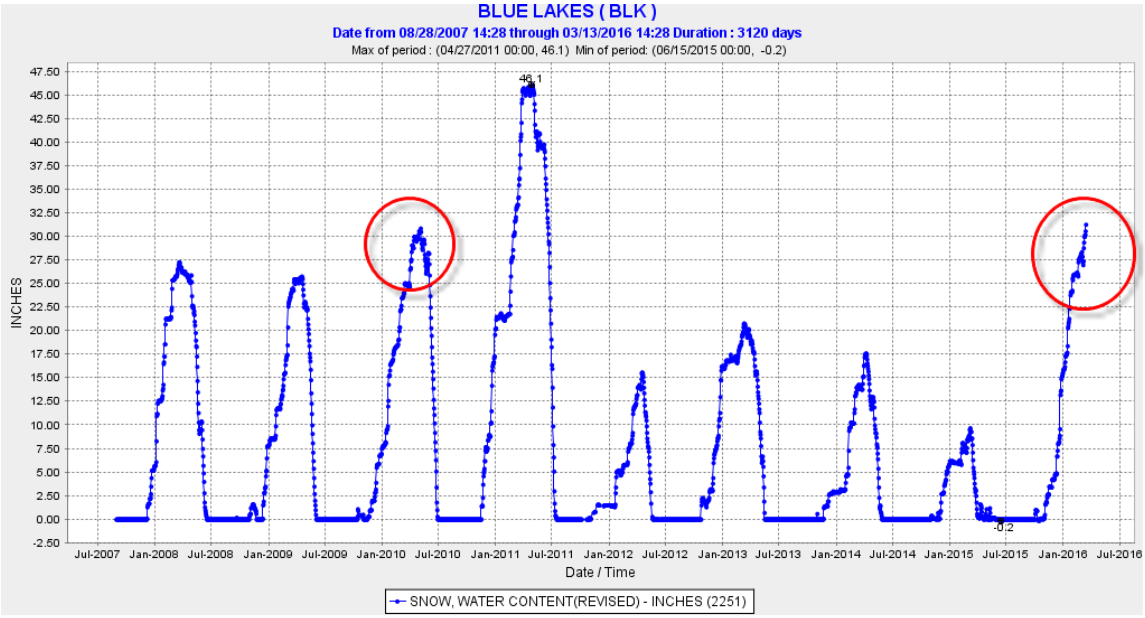

Figure 8: Snowpack in 2016 Similar to 2010

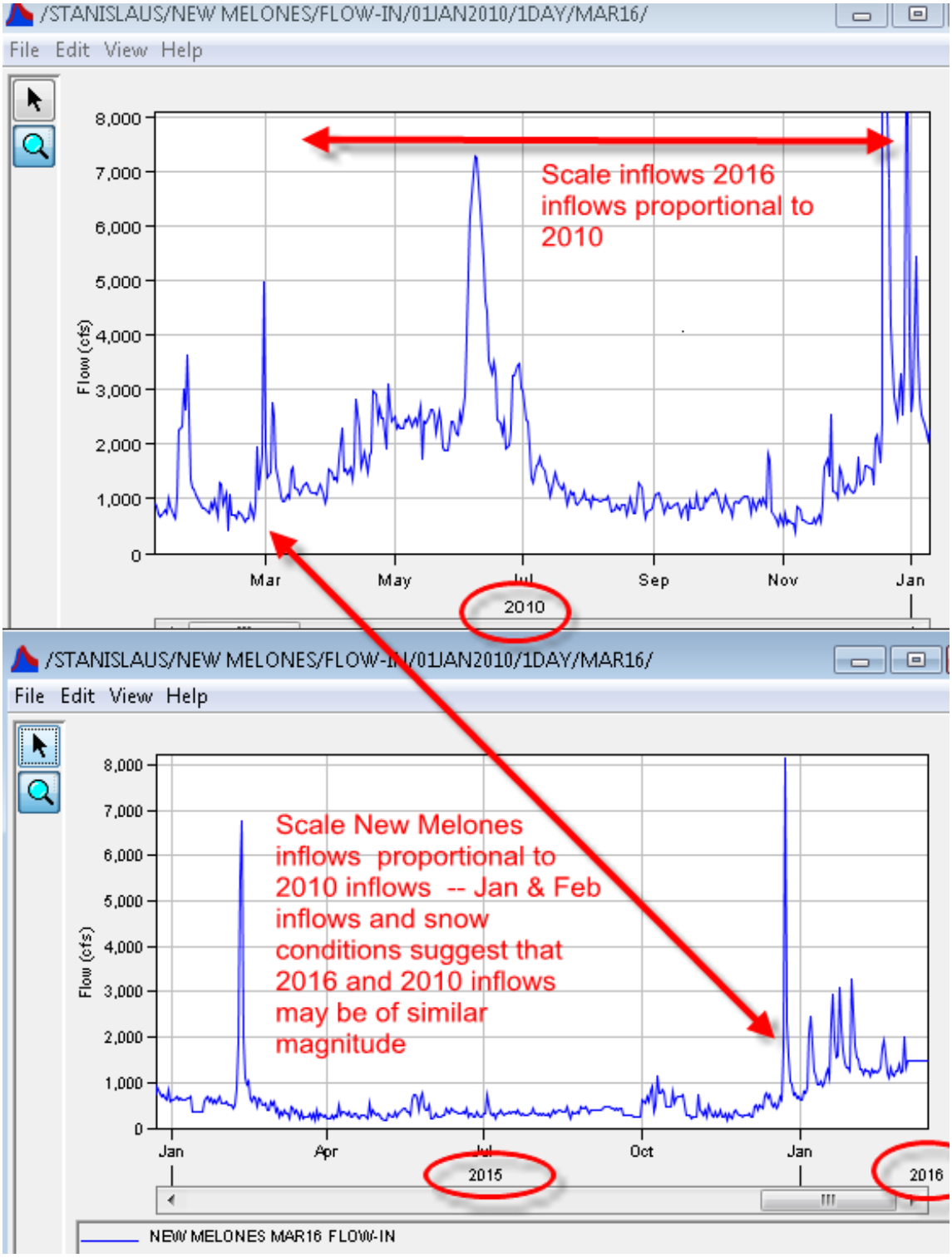

Figure 9: Pattering of New Melones Inflow in 2016 Based on 2010 Data

The meteorological data used (from March 9 to December 31) was based on the hourly data over the similar period in 2015.

It should be noted that another alternative for meteorological data was considered. This was the average meteorology for the past 5 years. Since the difference between the effect of the

two meteorological conditions on downriver temperatures was minimal, the 2015 meteorology was selected for this study.

3. Projected New Melones Storage

The projected New Melones end-of-month (EOM) storage as simulated with the model for the 90% UF and 75% UF is shown in the table and figure below.

	90% UF	75% UF
EOM	TAF	TAF
Feb-16	459	459
Mar-16	617	617
Apr-16	586	590
May-16	588	623
Jun-16	574	637
Jul-16	499	565
Aug-16	439	506
Sep-16	404	472
Oct-16	393	461
Nov-16	399	468
Dec-16	407	475

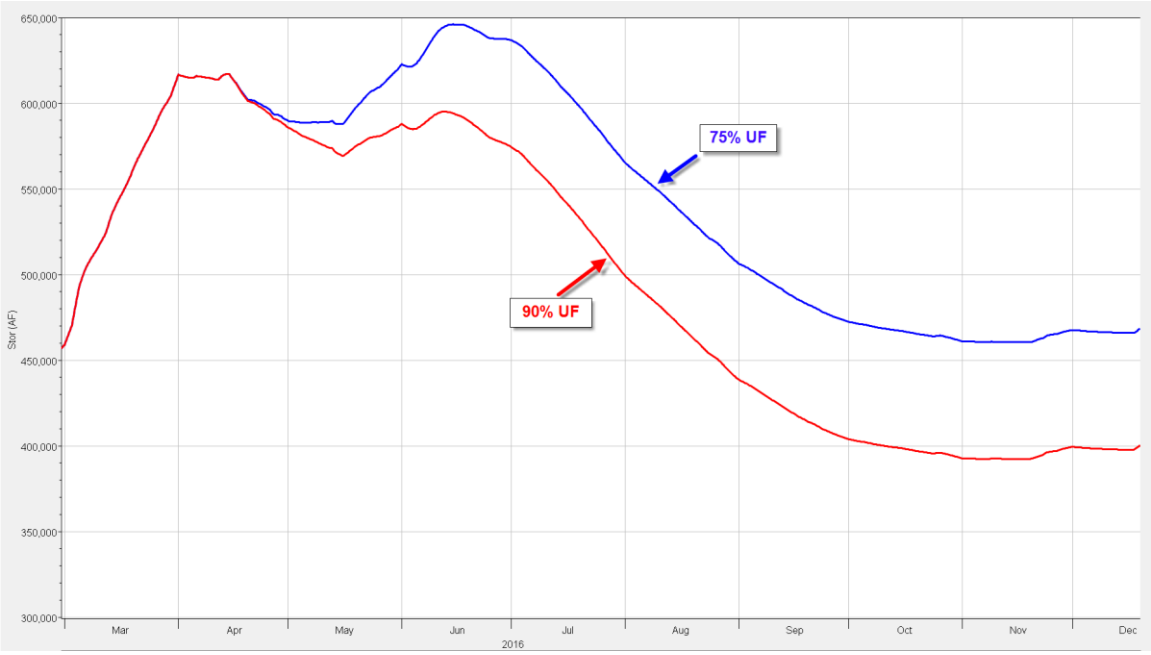

Figure 10 – New Melones Projected Storage

4. Projected Downriver Temperature Response

The projected downriver temperature is provided for six discrete points along the Stanislaus River:

1) **Below Goodwin Dam**
2) **Knights Ferry**
3) **Orange Blossom Bridge**
4) **Highway 120 Bridge (Oakdale)**
5) **Ripon Gage (Highway 99)**
6) **Above the confluence with the San Joaquin River**

The results are presented in two ways for the two alternatives (UF75 and UF90):

A. Graphical form (provided below) - showing the daily maximum temperatures.

B. Excel File: ***Stanislaus7DADM-March-20-2016_Study.xlsx*** (attached) - showing the 7-Days Average of Daily Maximums (7DADM).

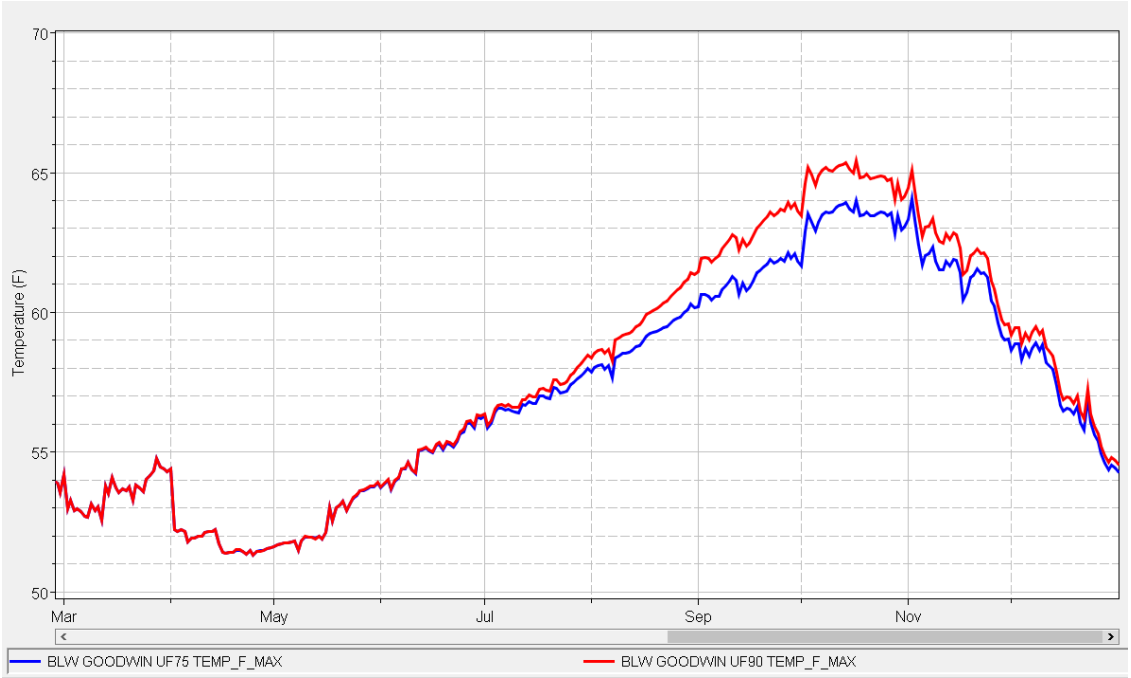

Figure 11 : Maximum Daily Temperatures below Goodwin Dam

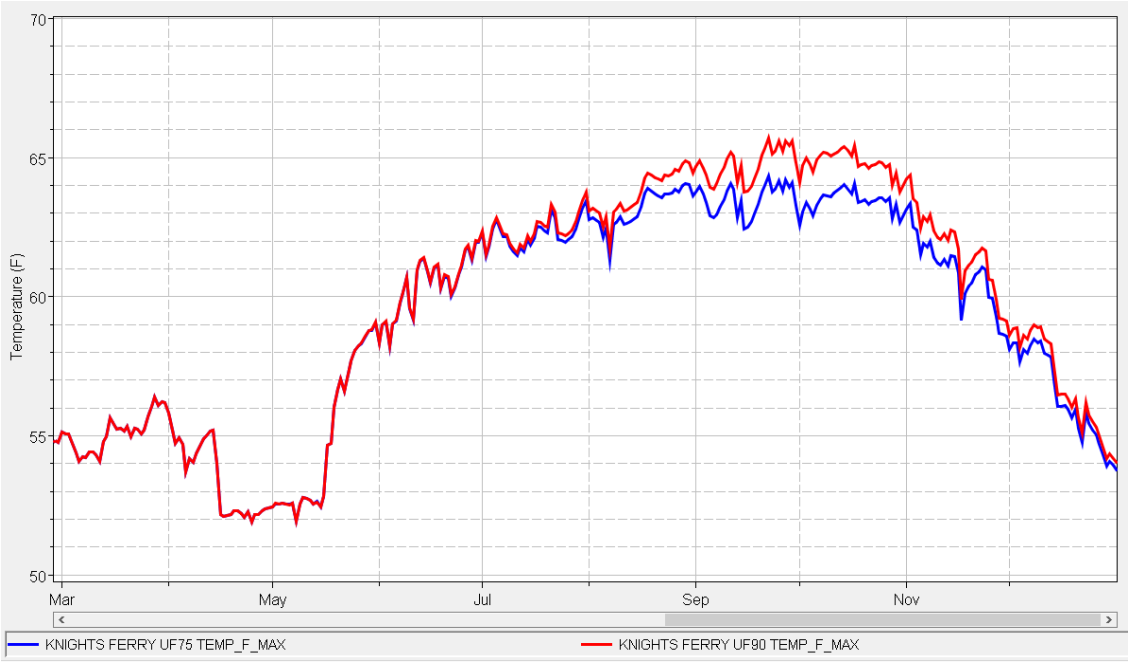

Figure 12 : Maximum Daily Temperatures at Knights Ferry

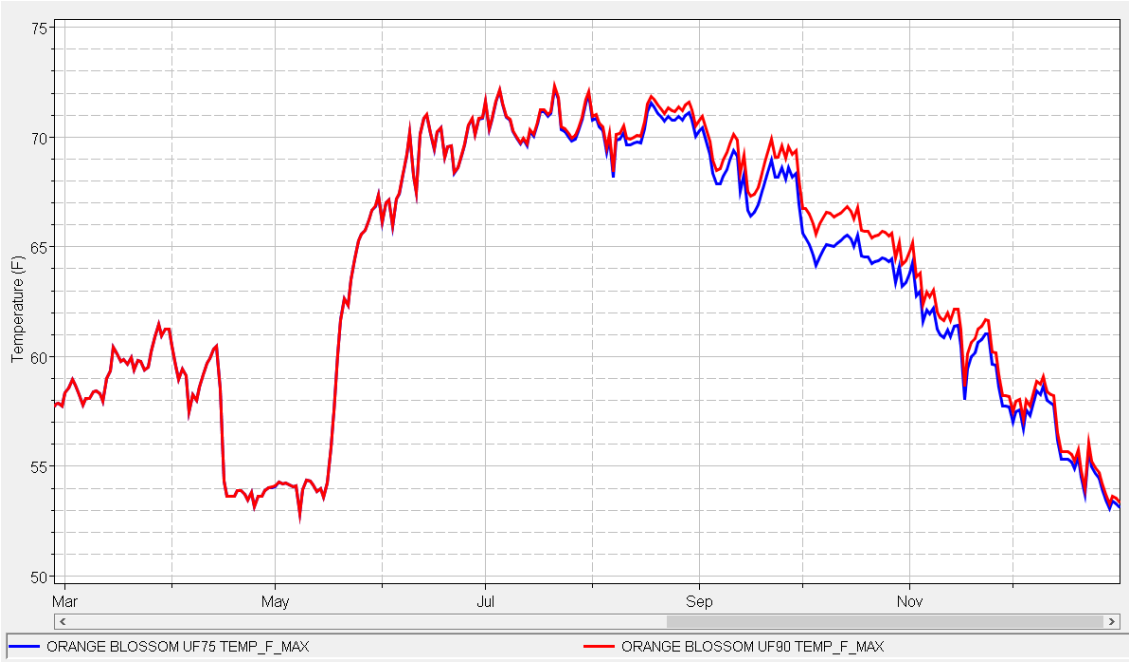

Figure 13 : Maximum Daily Temperatures at Orange Blossom Bridge

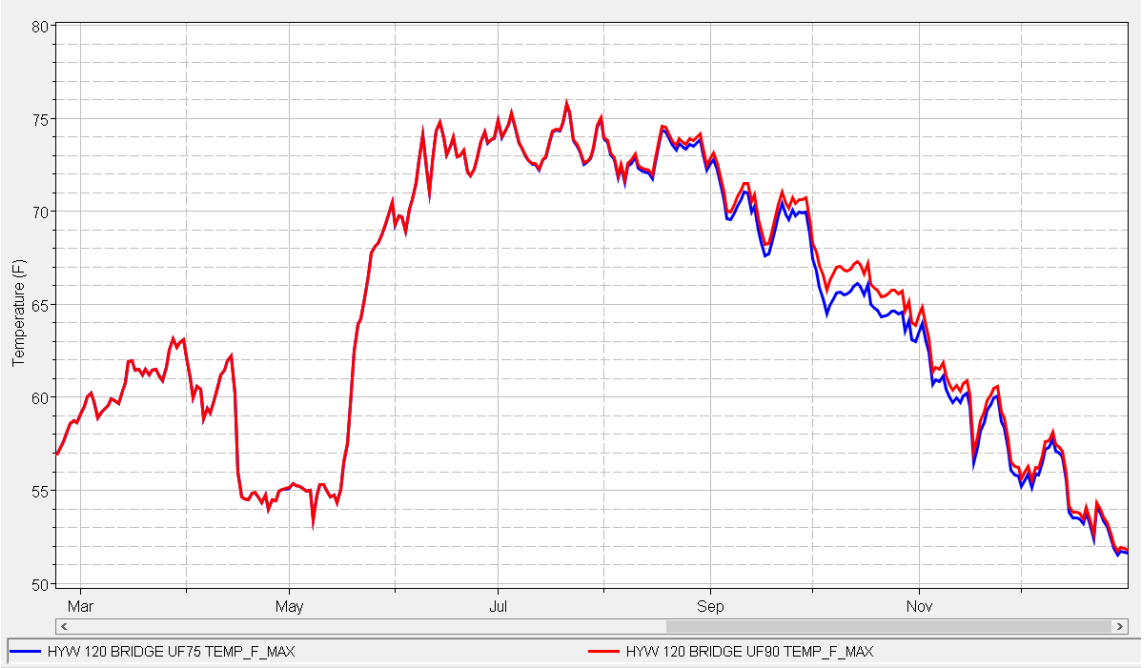

Figure 14 : Maximum Daily Temperatures below Highway 120 Bridge (Oakdale)

Figure 15 : Maximum Daily Temperatures at Ripon Gage (Highway 99)

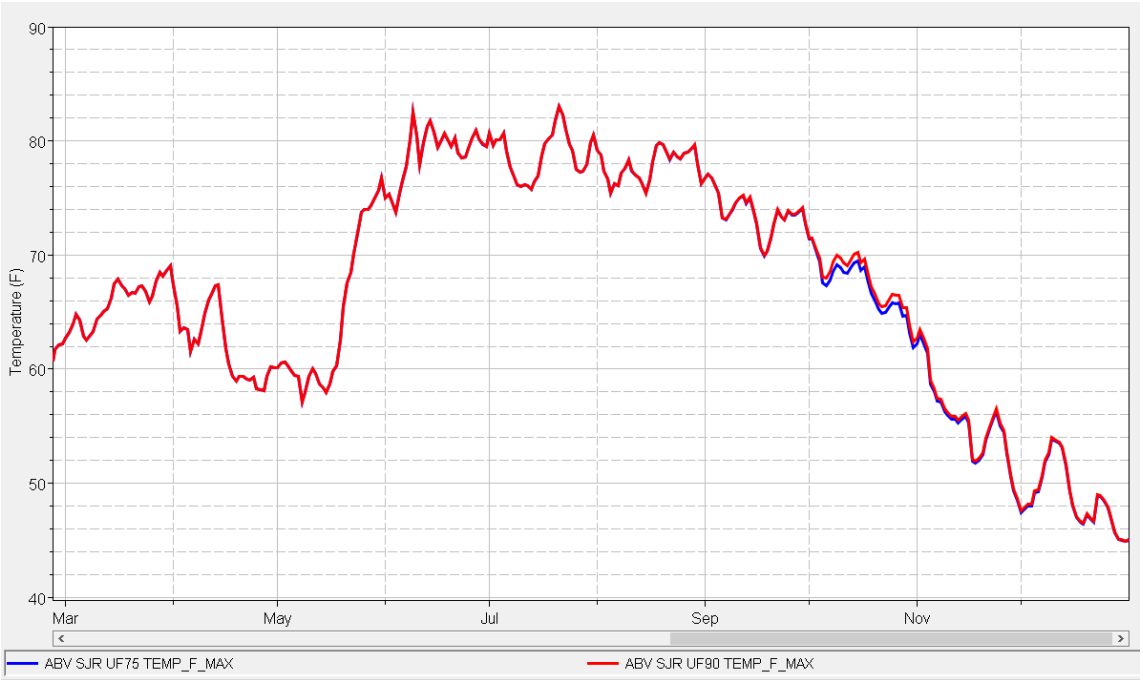

Figure 16 : Maximum Daily Temperatures above the Confluence with the San Joaquin River

5. Relationship between New Melones Storage and Below Goodwin Temperatures

The recent drought and the precipitous decline in New Melones storage provide us with a unique opportunity to gain insight of the relationship between New Melones storage and the temperature below Goodwin Dam.

It should be noted that this is just a crude assessment as the temperature is greatly influenced by the thermal structure of the reservoir which depends on depletion of cold/warm water from the reservoir resulting from preceding operation strategies.

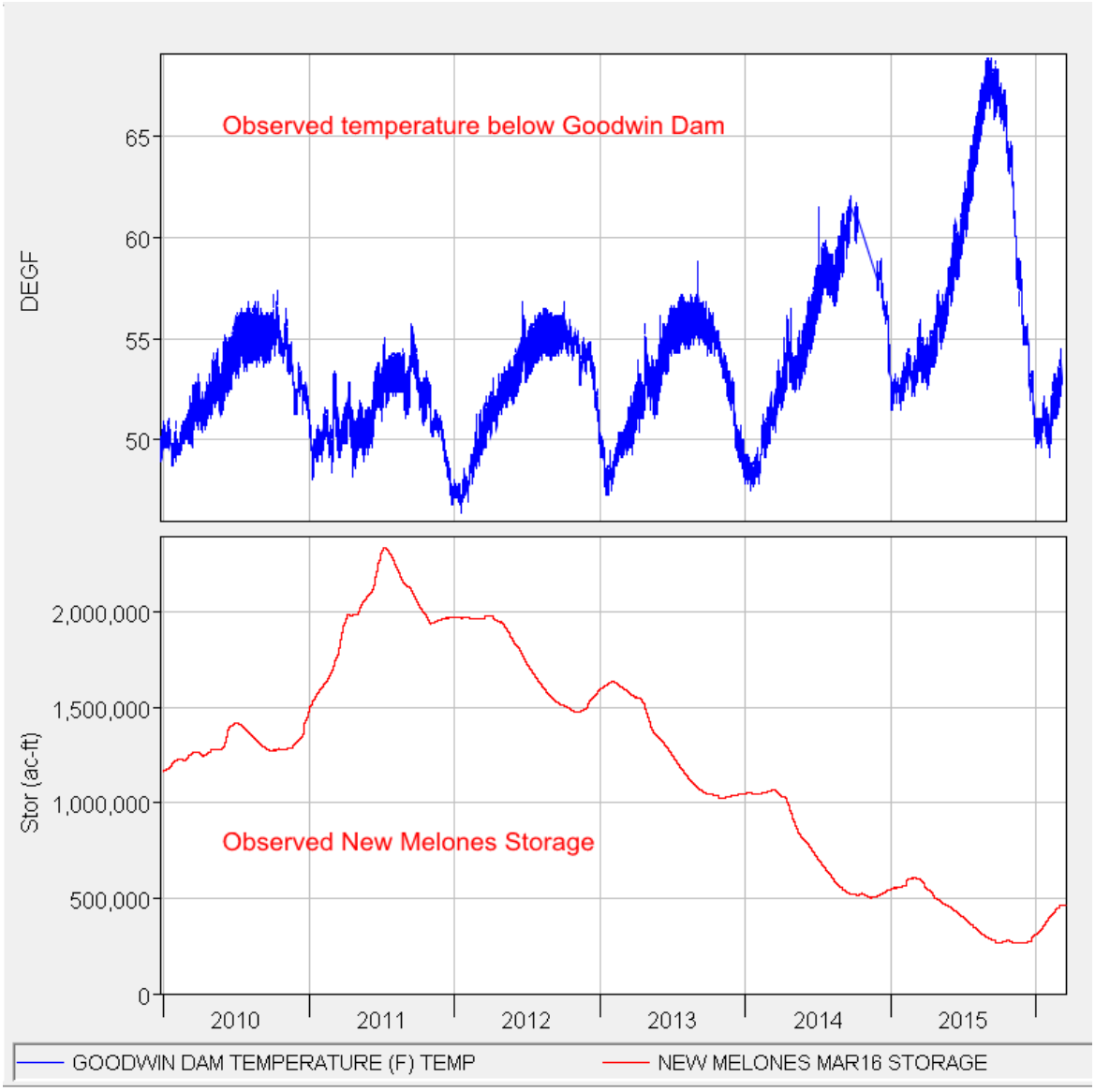

Figure 17 : Goodwin Observed Temperatures vs. New Melones Storage