2012 Temperature Work Group Products

Trinity River Restoration Program

Restore • Adapt • Improve

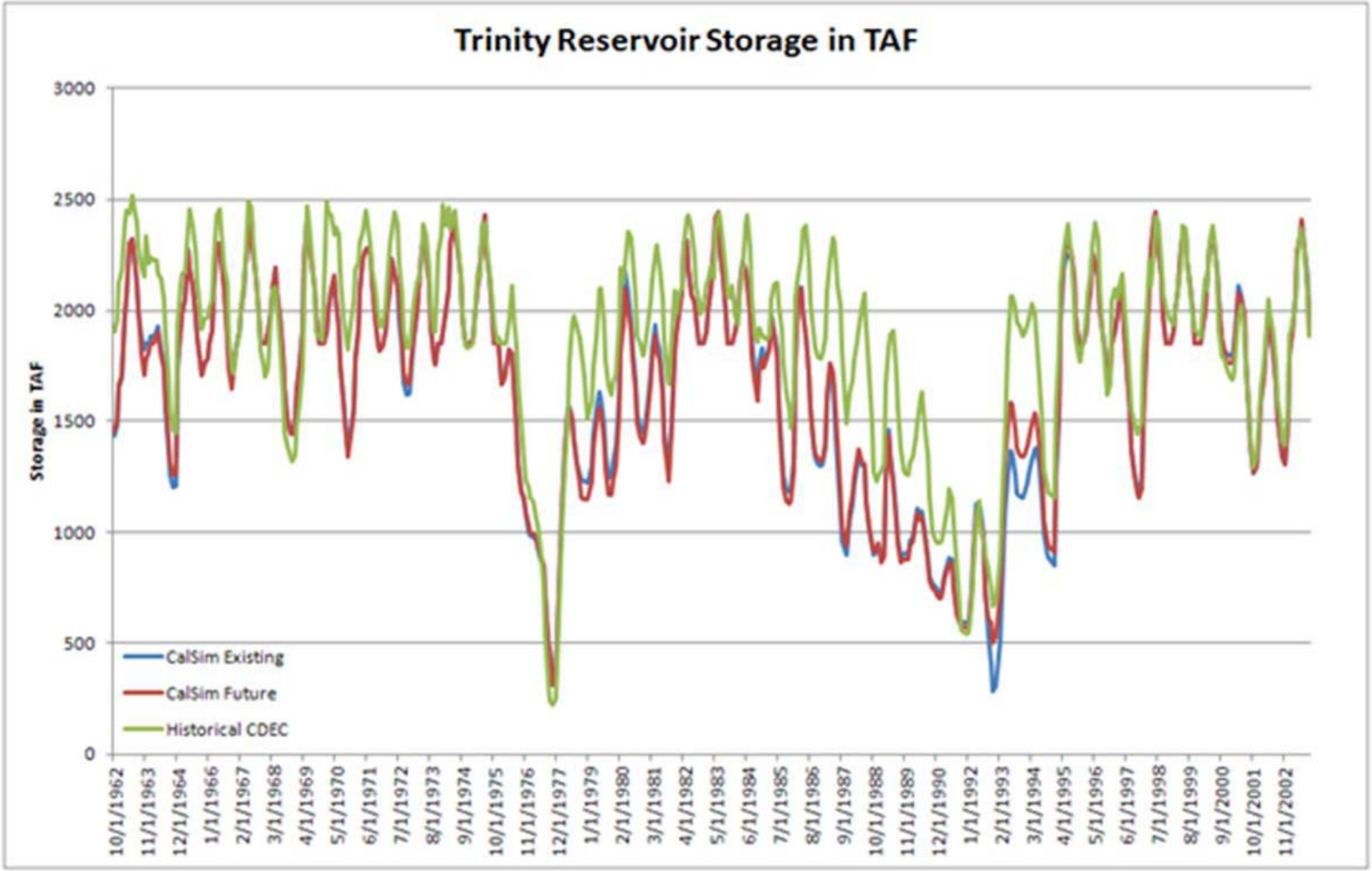
2012 Products

- Trinity Cold Water Pool Analysis
  - Reclamation TSC
- Lewiston Special Study
  - MP Region – MP700/200
- Inflow & Temperature Tracking
- Real-time Summer Temperature Management
- Historical Temperature Target Performance

Trinity Cold Water Pool Analysis

- Concept
  - Develop recommendations for EOS storage in Trinity Reservoir for periods of drought
- Analysis
  - CalSim analysis of historical meteorology fed into reservoir temperature-stage curve yields cold-water yield envelope

Trinity Cold Water Pool Analysis (Results)



Trinity Cold Water Pool Analysis (Results)

- Potential Impact of Climate Change
  - “Trinity Reservoir is sensitive to inflow water temperature. Just having a cold winter isn’t enough to cool the entire lake, the lake needs to be filled with cold water.”
    - Deas (1998)

Trinity Cold Water Pool Analysis (Conclusions)

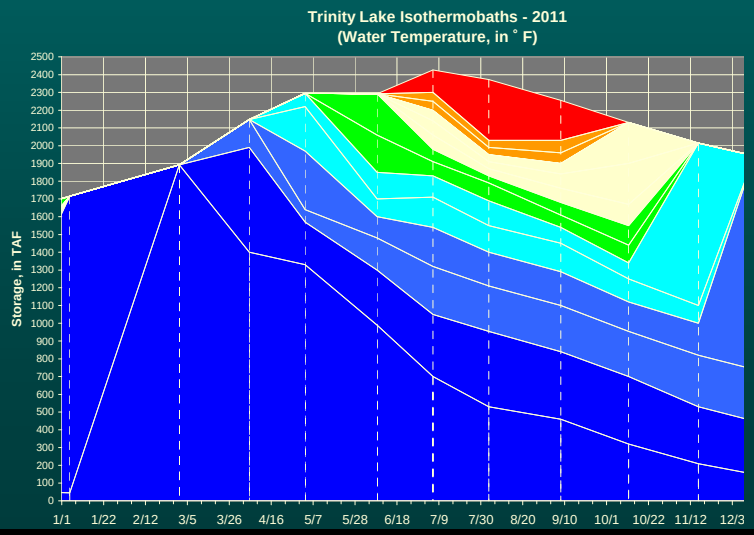
- A satisfactory relationship can be drawn between Trinity Reservoir storage conditions and Trinity River temperatures. End-of-September carryover of 750,000 AF or less could be thermally problematic, requiring use of the Trinity Dam auxiliary outlet to access cold water in support of downstream needs
- Historical operations, which did not include meeting ROD flows and RPAs, resulted in storage conditions which were often, but not always, able to accommodate acceptable release temperatures. Trinity operations under current criteria, which do include the ROD flows and RPAs, result in Trinity Reservoir end-of-September carryover storage volumes significantly less than 750,000 AF during drought periods, which may not provide sufficient cold water releases

Trinity Cold Water Pool Analysis (Conclusions)

- New operational criteria would need to be developed for balancing Trinity Reservoir operations with other CVP storage facilities in order to accommodate more desirable cold water pool end-of September carryover storage through extended drought periods
- In critically dry years, such as 1977, where storage capacity is already taxed, the lower level auxiliary outlet would likely need to be used extensively and cold water volume depleted to minimize releases of warm water from Trinity Reservoir

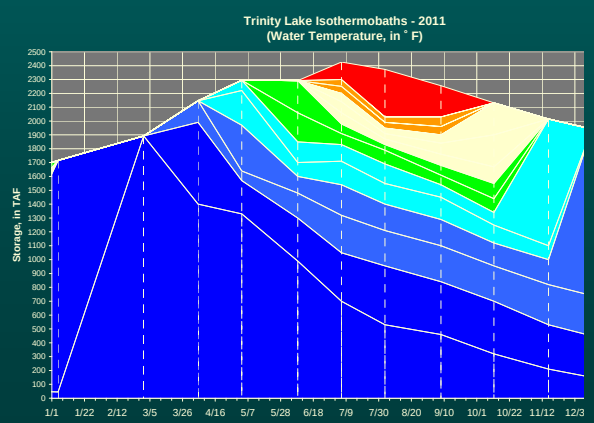
Trinity Cold Water Pool Analysis (Next Steps)

– Continue to refine understanding of the relationship between Trinity Reservoir elevation, releases for flows and exports, and temperature of Trinity River flows into Lewiston reservoir and develop correlation (Wittler/Zedonis)



Trinity Cold Water Pool Analysis (Next Steps)

- Use correlation & Calsim output to reproduce analysis
- Test system-wide operational changes over a range of Trinity Reservoir carryover storage during a severe multi-year drought by using modified CalSim assumptions



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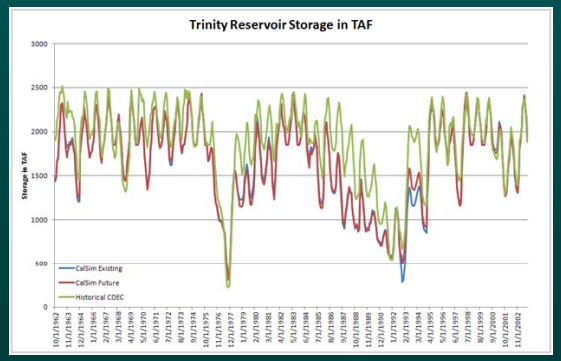

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Lewiston Special Study

- Concept
  - Imagine and cost alternatives that…
    - Improve cold water transmission upstream of Lewiston Dam
    - Increase salmon production
    - Increase the available mileage of salmonid habitat on the Trinity River
    - Maintain existing level of recreational benefits and minimize impacts to same

Lewiston Special Study (cont.)

- Analysis
  - Contract & Field Cost Estimates for all alternatives and options
- Results
  - Report issued Sept 28, 2012 by USBR MP-700/200

Lewiston Special Study (cont.)

Alternatives

- 1a. Removal of Lewiston Dam - Canal Water Supply
- 1b. Removal of Lewiston Dam - Pump Station Water Supply
- 2. Dredging of Lewiston Reservoir
- 3a. Tunnel from Trinity Dam to Lewiston Dam
- 3b. Pipeline from Trinity Dam to Lewiston Dam
- 4. Raise Lewiston Dam

Lewiston Special Study (Options)

A. Lewiston Powerplant Intake Extension Modification

- The TPUD has proposed a replacement 2.2-MW power plant at Lewiston Dam

B. Trinity Dam Selective Withdrawal Structure

- Reclamation considered the concept of a Trinity Dam elective withdrawal structure in studies conducted in 1978 and 1979

Lewiston Special Study (cont.)

- Contract Cost is the estimated bid for the construction contract
- Field Cost is the Contract Cost plus an allowance for “typical” unforeseen costs such as claims, overruns, etc.
- Construction Cost is the Field Cost plus “non-contract costs”

Table 1 - Summary of Cost Estimates

Alternative/Option	Contract Cost	Field Cost	Construction Cost
1a - Removal of Lewiston Dam - Canal Water Supply	$145,000,000	$180,000,000	$250,000,000
1b - Removal of Lewiston Dam - Pump Station Water Supply	$140,000,000	$175,000,000	$250,000,000
2 - Dredging of Lewiston Reservoir	$12,500,000	$15,500,000	$22,000,000
3a - Tunnel from Trinity Dam to Lewiston Dam	$280,000,000	$350,000,000	$490,000,000
3b - Pipeline from Trinity Dam to Lewiston Dam	$165,000,000	$210,000,000	$290,000,000
4 - Raise Lewiston Dam	$18,500,000	$23,000,000	$32,000,000
Option A - Lewiston Powerplant Intake Extension Modification	$1,050,000	$1,300,000	$1,800,000
Option B - Trinity Dam Selective Withdrawal Structure	$96,000,000	$120,000,000	$170,000,000

Lewiston Special Study (cont.)

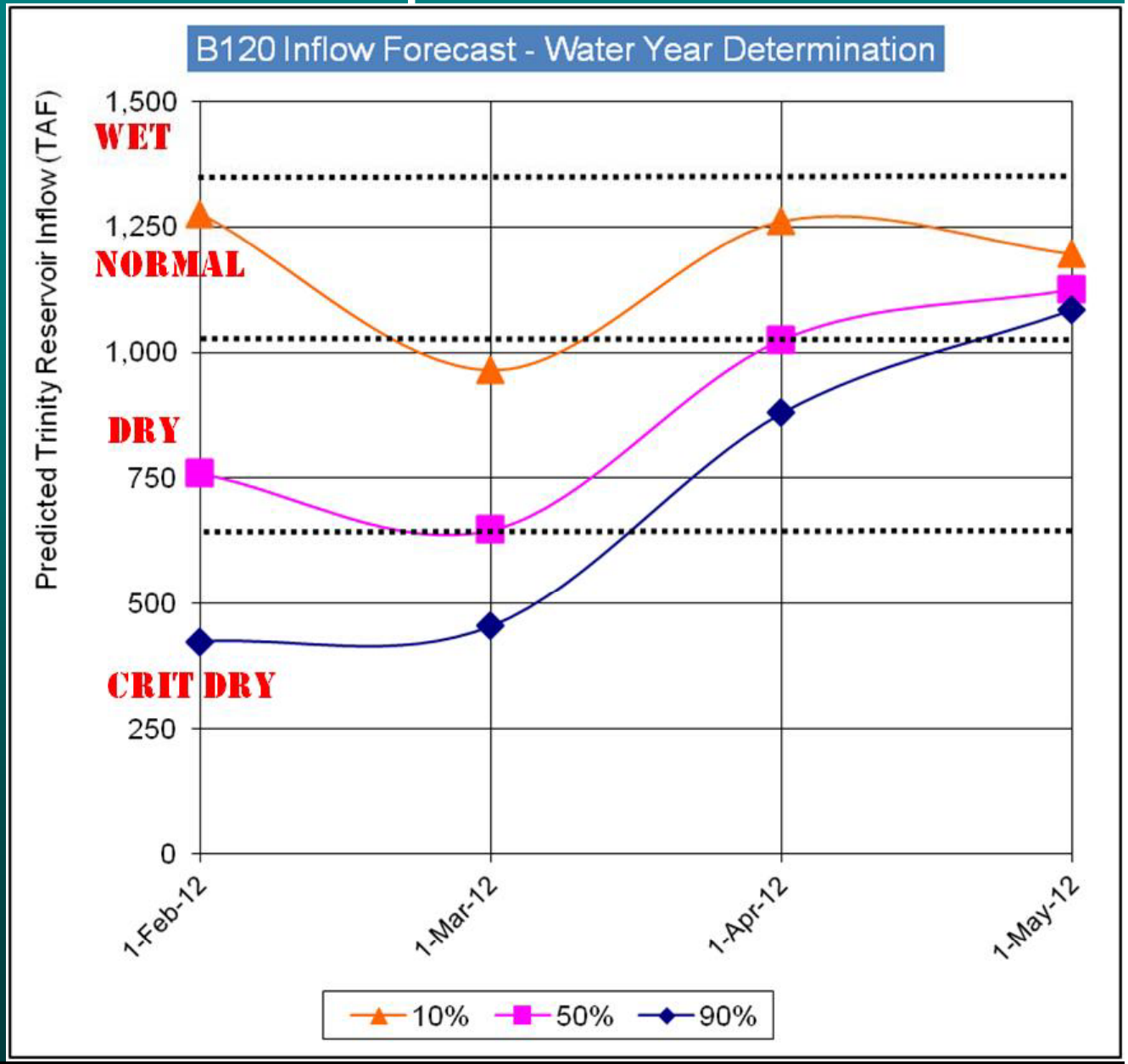
- Next Steps
  - Apply Reclamation planning process
  - Prioritize goals
  - Establish objectives
  - Conduct analyses of selected alternatives with existing tools
  - Work with TPUD to evaluate benefit of extending Lewiston Power Plant intake
  - Explore operational impacts on cold water transmission through Lewiston (SRTTG)

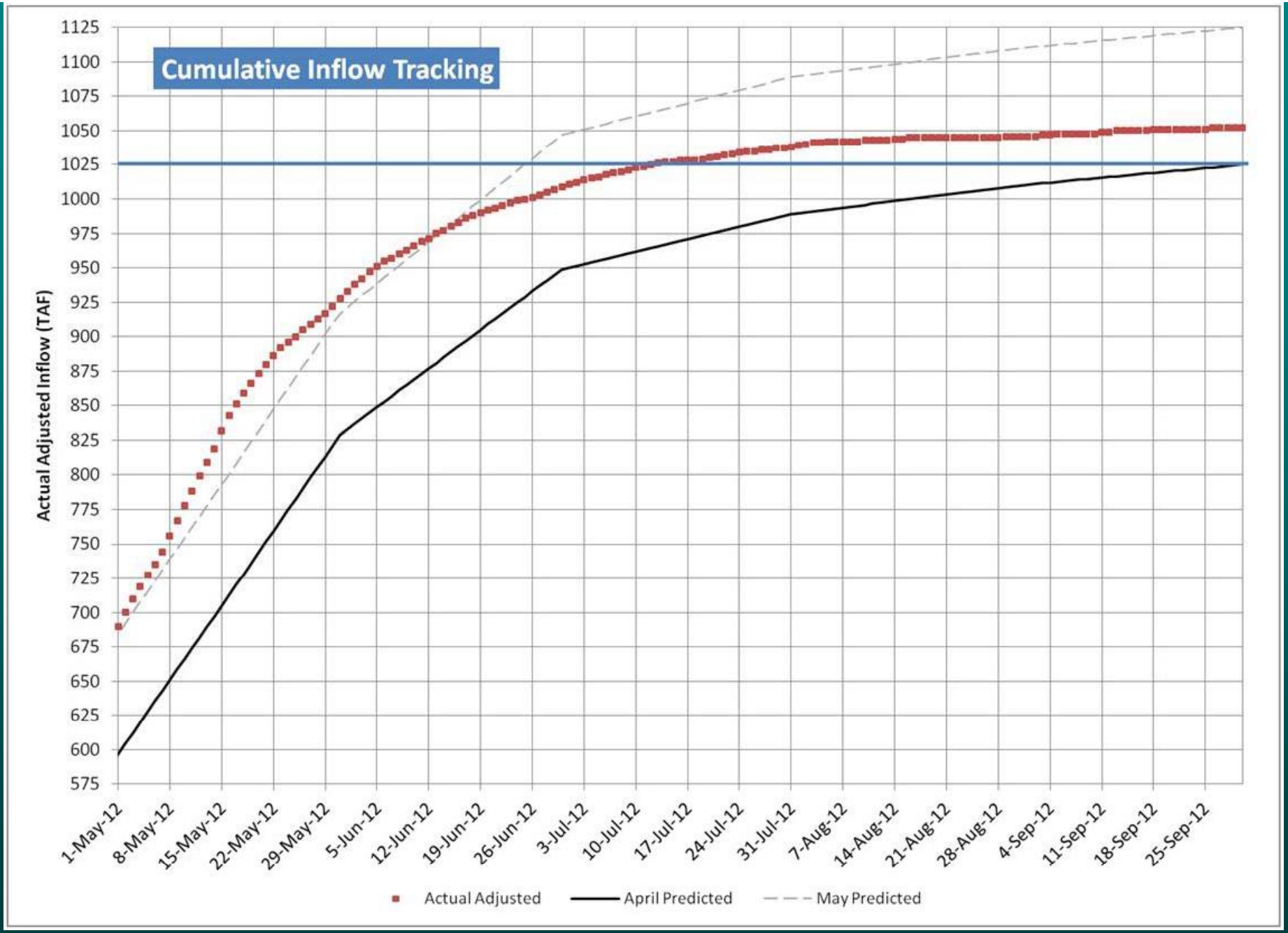
Inflow & Temperature Tracking

- Concept
  - Joint (Flow & Temp WG's) tracking of reservoir inflow/outflow & temperature target performance
- Analyses
  - Trinity Reservoir Inflow
    - Forecast/Actual comparison
  - Trinity River Hydrograph
    - TMC Prescribed/ROD/Actual comparison
  - Trinity & Lewiston reservoirs model performance
  - Trinity River temperature target tracking

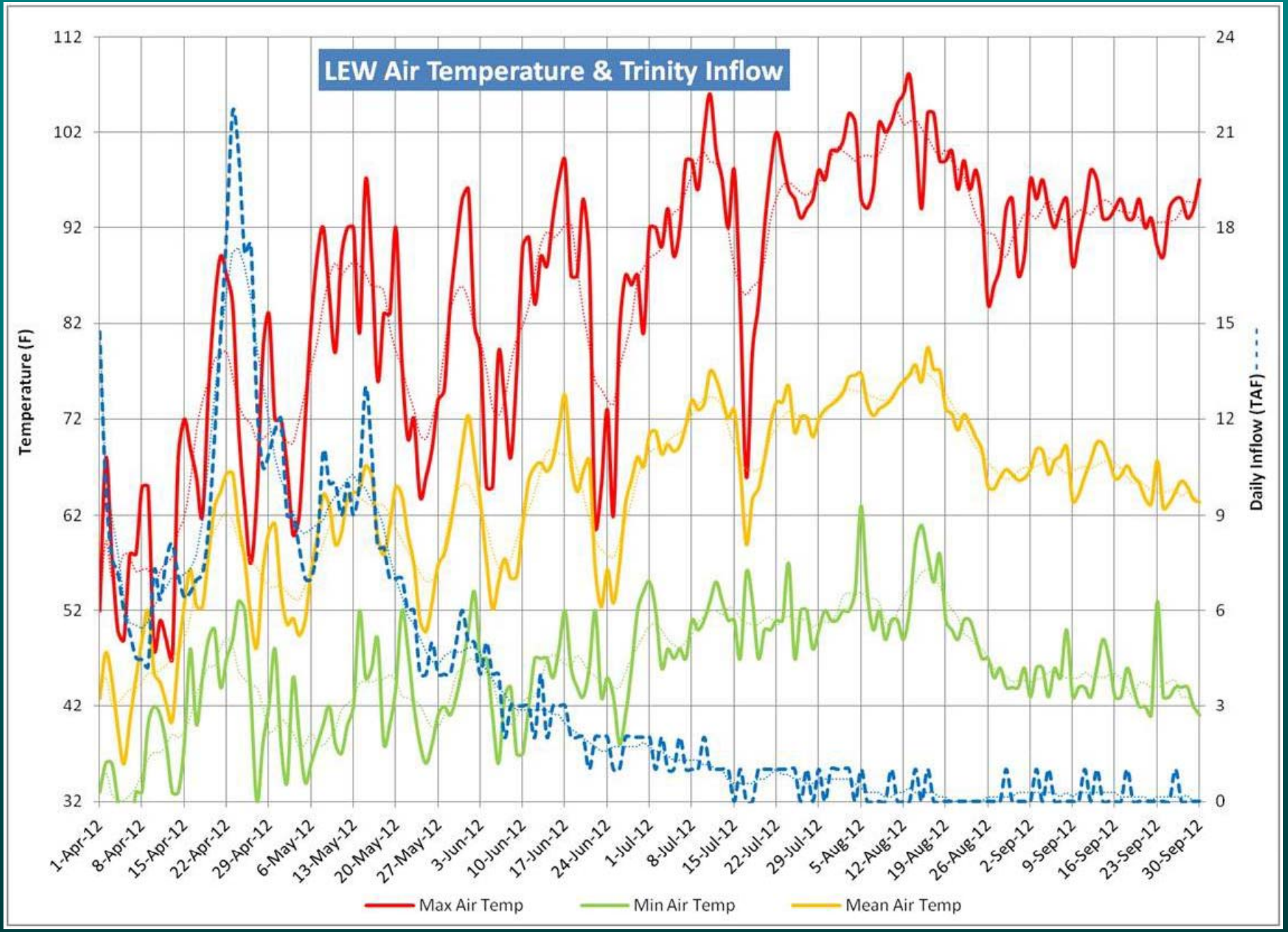
WY2012 Update

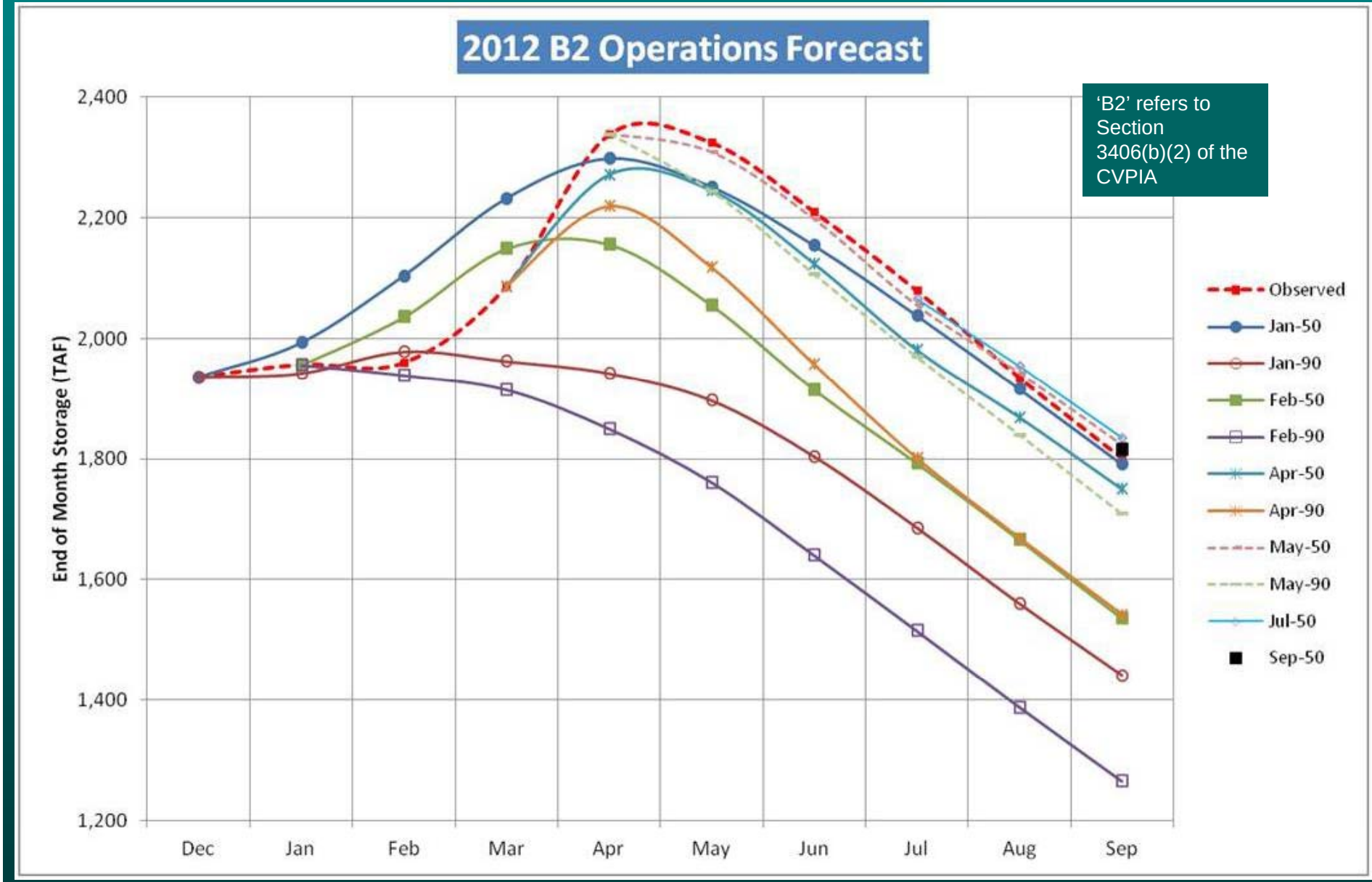
Bulletin 120 is a publication issued four times a year, in the second week of February, March, April, and May by the California Department of Water Resources. It contains forecasts of the volume of seasonal runoff from the state's major watersheds, and summaries of precipitation, snowpack, reservoir storage, and runoff in various regions of the State.

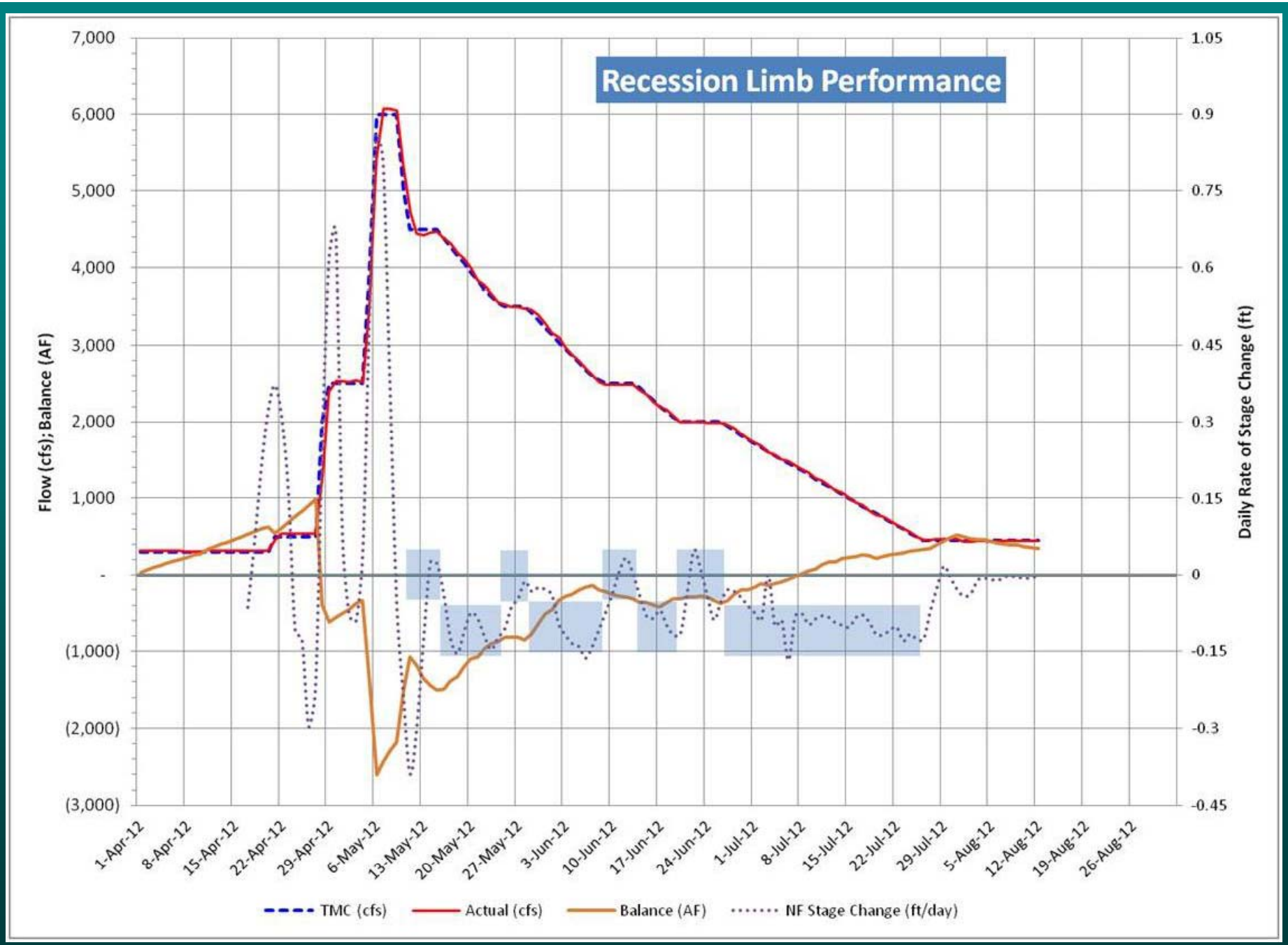


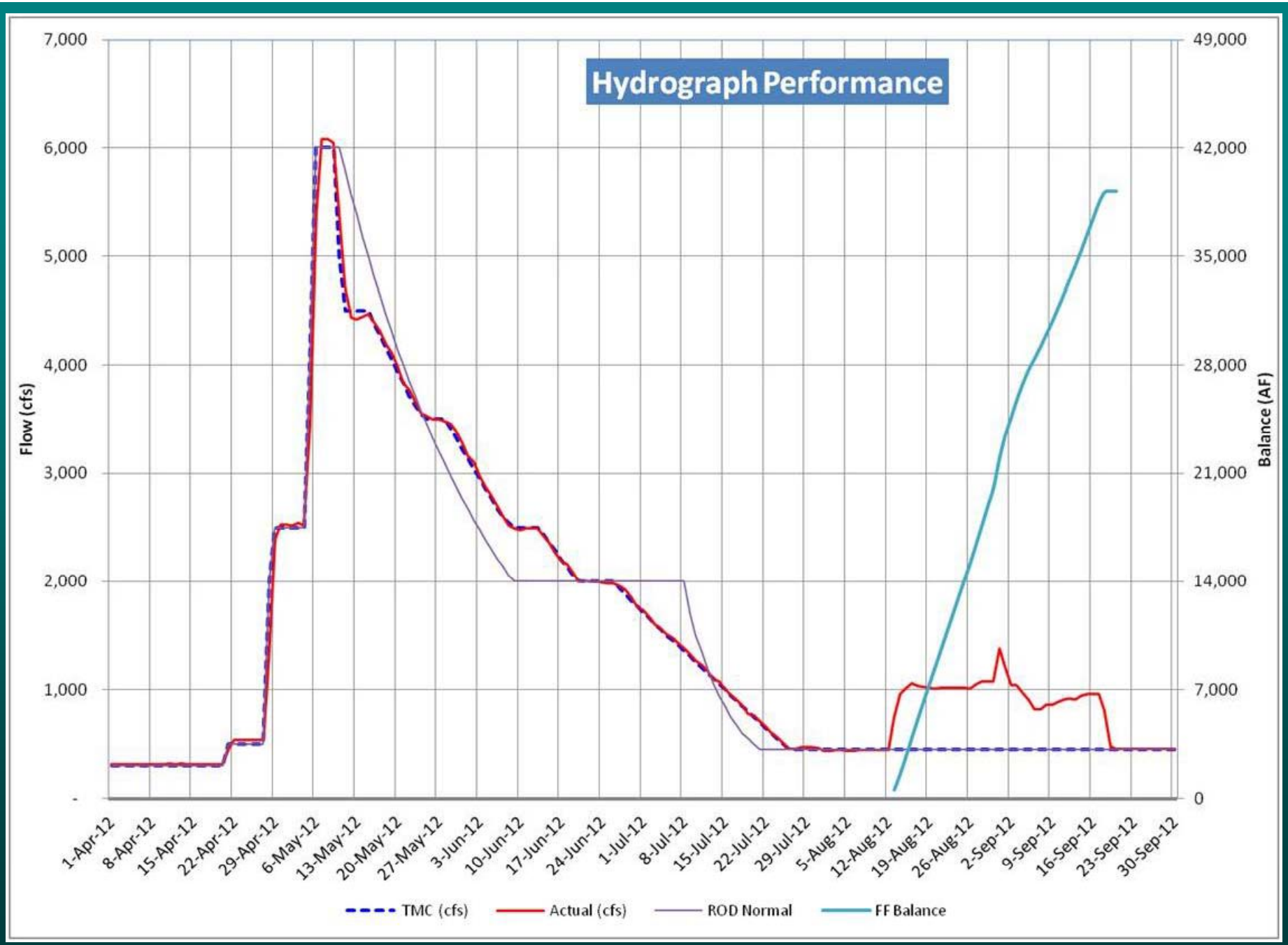


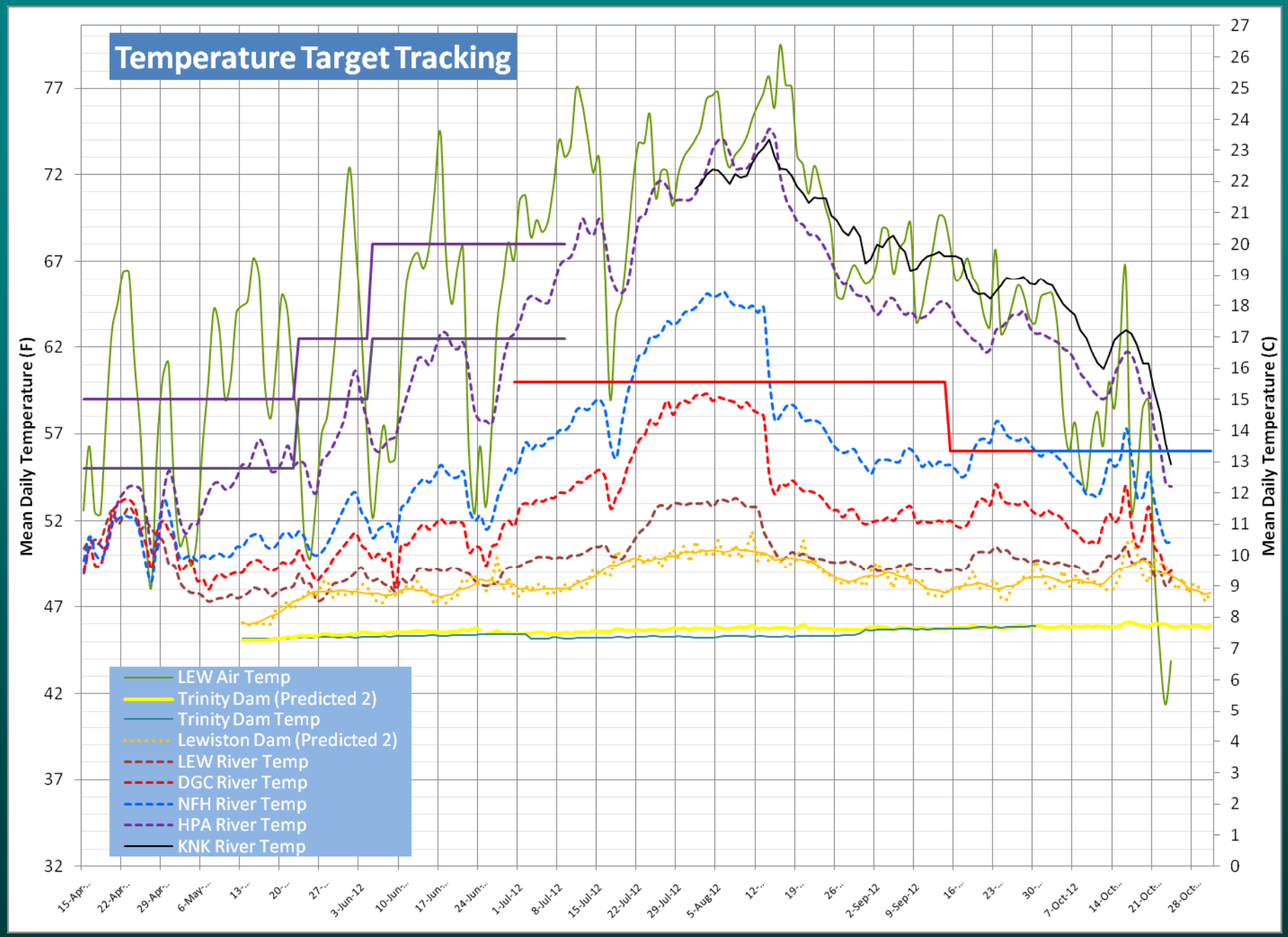
The Actual Adjusted estimate includes inflow between Trinity and Lewiston Dams.


LEW Air Temperature & Trinity Inflow
Temperature (F)
Daily Inflow (TAF)
112
102
92
82
72
62
52
42
32
24
21
18
15
12
9
6
3
0
1-Apr-12
8-Apr-12
15-Apr-12
22-Apr-12
29-Apr-12
6-May-12
13-May-12
20-May-12
27-May-12
3-Jun-12
10-Jun-12
17-Jun-12
24-Jun-12
1-Jul-12
8-Jul-12
15-Jul-12
22-Jul-12
29-Jul-12
5-Aug-12
12-Aug-12
19-Aug-12
26-Aug-12
2-Sep-12
9-Sep-12
16-Sep-12
23-Sep-12
30-Sep-12
Max Air Temp
Min Air Temp
Mean Air Temp


2012 B2 Operations Forecast
'B2' refers to Section 3406(b)(2) of the CVPIA
End of Month Storage (TAF)
2,400
2,200
2,000
1,800
1,600
1,400
1,200
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Observed
Jan-50
Jan-90
Feb-50
Feb-90
Apr-50
Apr-90
May-50
May-90
Jul-50
Sep-50

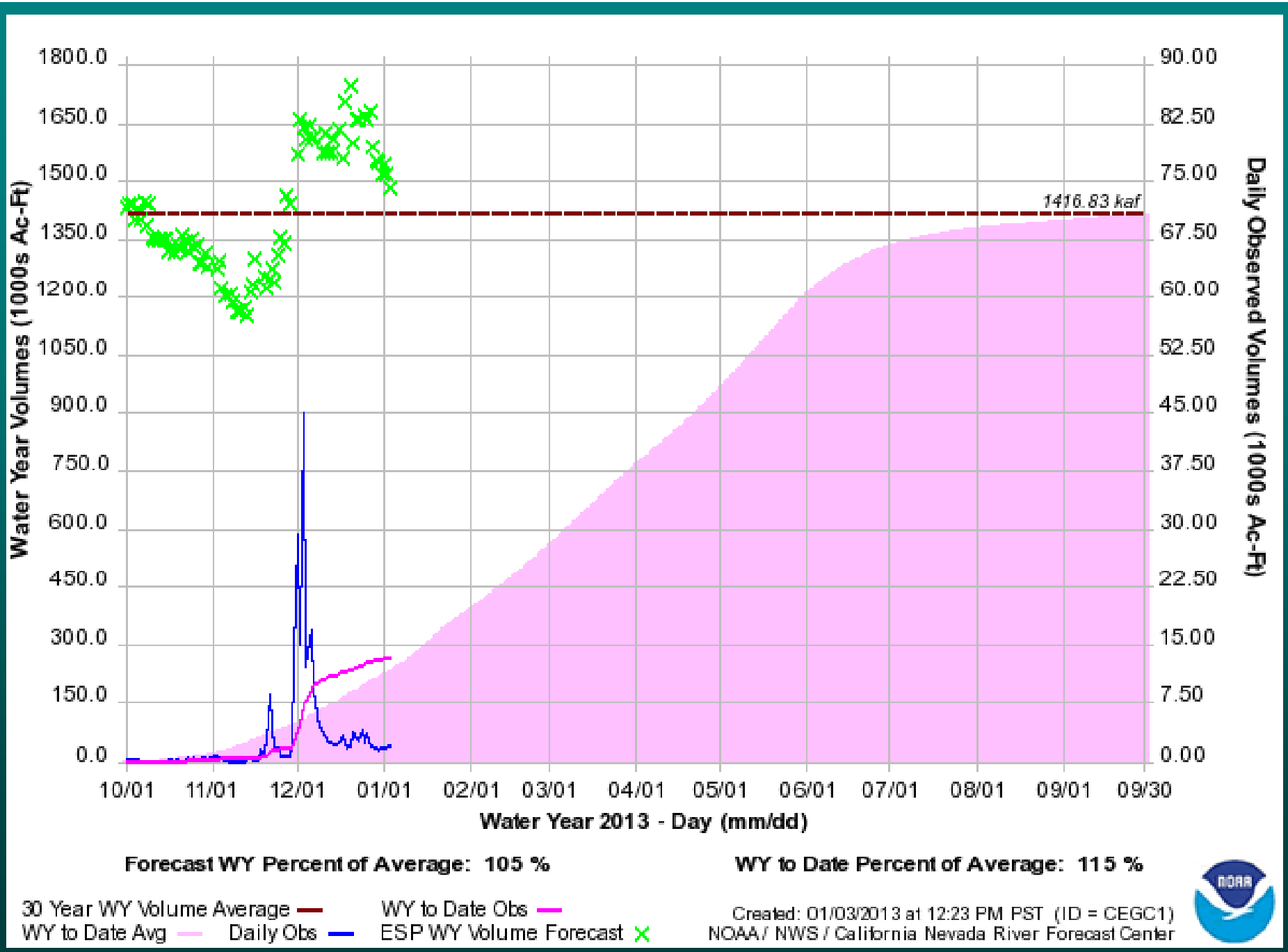

Recession Limb Performance
Flow (cfs); Balance (AF)
Daily Rate of Stage Change (ft)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
-
(1,000)
(2,000)
(3,000)
1.05
0.9
0.75
0.6
0.45
0.3
0.15
0
-0.15
-0.3
-0.45
1-Apr-12
8-Apr-12
15-Apr-12
22-Apr-12
29-Apr-12
6-May-12
13-May-12
20-May-12
27-May-12
3-Jun-12
10-Jun-12
17-Jun-12
24-Jun-12
1-Jul-12
8-Jul-12
15-Jul-12
22-Jul-12
29-Jul-12
5-Aug-12
12-Aug-12
19-Aug-12
26-Aug-12
TMC (cfs)
Actual (cfs)
Balance (AF)
NF Stage Change (ft/day)


Hydrograph Performance
Flow (cfs)
Balance (AF)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
-
49,000
42,000
35,000
28,000
21,000
14,000
7,000
0
1-Apr-12
8-Apr-12
15-Apr-12
22-Apr-12
29-Apr-12
6-May-12
13-May-12
20-May-12
27-May-12
3-Jun-12
10-Jun-12
17-Jun-12
24-Jun-12
1-Jul-12
8-Jul-12
15-Jul-12
22-Jul-12
29-Jul-12
5-Aug-12
12-Aug-12
19-Aug-12
26-Aug-12
2-Sep-12
9-Sep-12
16-Sep-12
23-Sep-12
30-Sep-12
TMC (cfs)
Actual (cfs)
ROD Normal
FF Balance


Temperature Target Tracking
Mean Daily Temperature (F)
Mean Daily Temperature (C)
77
72
67
62
57
52
47
42
37
32
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
15-Apr-...
22-Apr-...
29-Apr-...
6-May-...
13-...
20-...
27-...
3-Jun-12
10-Jun-...
17-Jun-...
24-Jun-...
1-Jul-12
8-Jul-12
15-Jul-12
22-Jul-12
29-Jul-12
5-Aug-12
12-...
19-...
26-...
2-Sep-12
9-Sep-12
16-...
23-...
30-...
7-Oct-12
14-Oct-...
21-Oct-...
28-Oct-...
LEW Air Temp
Trinity Dam (Predicted 2)
Trinity Dam Temp
Lewiston Dam (Predicted 2)
LEW River Temp
DGC River Temp
NFH River Temp
HPA River Temp
KNK River Temp

Inflow & Temperature Tracking (cont.)

- Conclusions
  - Informative in-season updates
  - Facilitates coordination with CVO & partners
  - Documents progress on work group objectives
- Next Steps
  - Continue to refine in WY2013
  - Integrate with Real-time ‘paper’ exercise
  - Take steps to automate & transfer parts to TRRP.NET


1800.0
1650.0
1500.0
1350.0
1200.0
1050.0
900.0
750.0
600.0
450.0
300.0
150.0
0.0
Water Year Volumes (1000s Ac-Ft)
90.00
82.50
75.00
67.50
60.00
52.50
45.00
37.50
30.00
22.50
15.00
7.50
0.00
Daily Observed Volumes (1000s Ac-Ft)
1416.83 kaf
10/01
11/01
12/01
01/01
02/01
03/01
04/01
05/01
06/01
07/01
08/01
09/01
09/30
Water Year 2013 - Day (mm/dd)
Forecast WY Percent of Average: 105 %
WY to Date Percent of Average: 115 %
30 Year WY Volume Average
WY to Date Obs
WY to Date Avg
Daily Obs
ESP WY Volume Forecast
Created: 01/03/2013 at 12:23 PM PST (ID = CEGC1)
NOAA/ NWS / California Nevada River Forecast Center

Real-time Summer Temperature Management

- Concept
  - Can we manage weekly summer flows to increase certainty of meeting DGC & NFH temperature targets?
- Analysis
  - Concepts tested using RMA 2/11 hydrodynamic water quality model

Real-time Summer Temperature Management (Analysis)

- Water Years 2003 (Wet) & 2005 (Normal)
- Time period of interest
  - From July 1st through September 30th
- Spatial extent of study
  - Upper Trinity River Reach, Lewiston to Douglas City
- Forecasting criteria and/or limitations
  - Air temperature (10 day forecast)
  - Water availability for water temperature purposes (reserve water in a period when it doesn't cause a temperature exceedance for release at a time when it could prevent an exceedance)

Real-time Summer Temperature Management (Analysis)

- Two Scenarios
  - 1st Alternative – Meet WR 90-5 targets
  - 2nd Alternative – 0.5°C Below WR 90-5 targets

  - Key Assumption
    - Lewiston release temperatures near seasonal historical norms

Model Runs (sensitivity)

Model Scenarios. Year 2003

Flow Scenario		No. of days with daily mean water temperature above Water Temperature Criteria Targets[1]
1.	Historic Flow[4] (meas. Tw)	11
2.	Historic Flow[4] (sim. Tw)	15
3.	350 cfs fixed flow rate[5]	44
4.	400 cfs fixed flow rate[5]	22
5.	450 cfs fixed flow rate[5]	21
6.	500 cfs fixed flow rate[5]	16
7.	550 cfs fixed flow rate[5]	12
8.	600 cfs fixed flow rate[5]	9
9.	650 cfs fixed flow rate[5]	4
10.	700 cfs fixed flow rate[5]	1
11.	1st Alternative flow regime[5]	0[6]
12.	2nd Alternative flow regime[5]	0

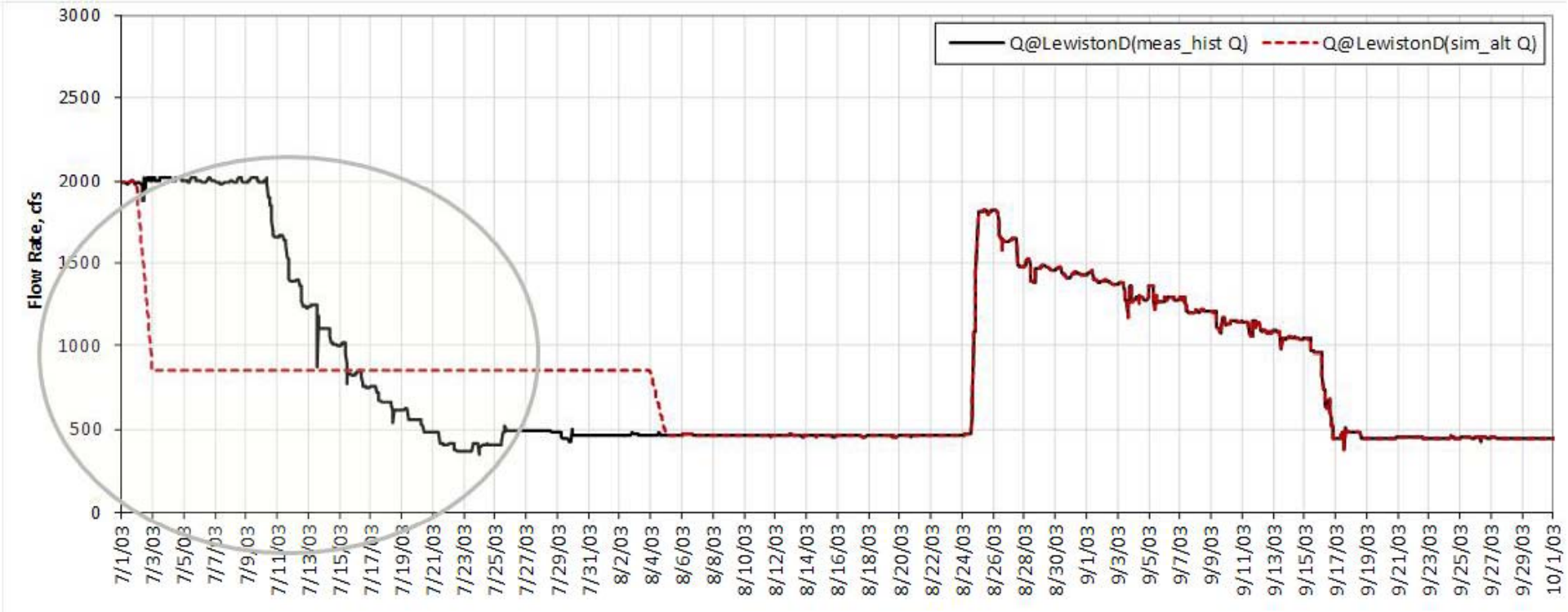
Model Runs (sensitivity)

Model Scenarios. Year 2005

Flow Scenario		No. of days with daily mean water temperature above Water Temperature Criteria Targets[1]
1.	Historic Flow[4] (meas. Tw)	25 [5]
2.	Historic Flow[4] (sim. Tw)	29 [5]
3.	350 cfs fixed flow rate[6]	57
4.	400 cfs fixed flow rate[6]	46
5.	450 cfs fixed flow rate[6]	35
6.	500 cfs fixed flow rate[6]	29
7.	550 cfs fixed flow rate[6]	23
8.	600 cfs fixed flow rate[6]	15
9.	650 cfs fixed flow rate[6]	10
10.	700 cfs fixed flow rate[6]	5
11.	1st Alternative flow regime[6]	0
12.	2nd Alternative flow regime[6]	0[7]

Key Finding

- Sensitivity simulations showed storing water by reducing Q<450 cfs is generally infeasible – i.e., insufficient volumes could be reserved for future temperature management. So, in subsequent simulations water from the 2000 cfs bench was reserved for later use



Results - 2003

- Used “simple” weather forecast to estimate water needs to meet zero exceedances at (a) temperature target and (b) temperature target minus 0.5C

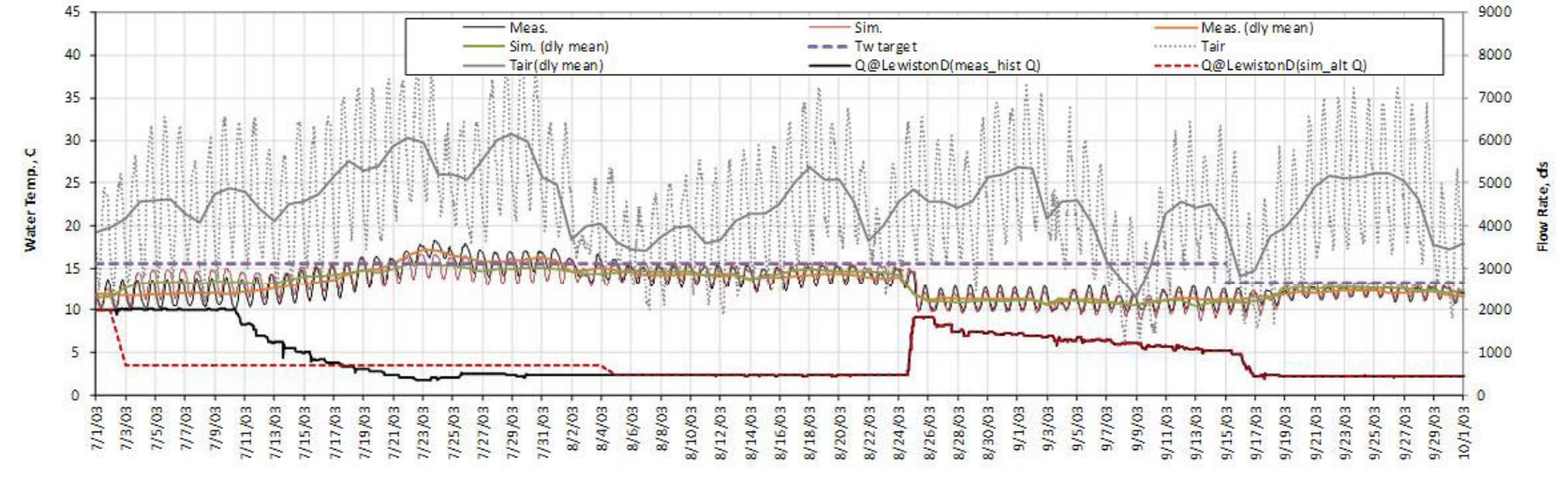


Figure 19. Scenario with the first alternative flow regime. Measured water temperature vs. Simulated water temperature, Measured flow rate vs. Simulated flow rate, Trinity River water temperature targets, air temperature. Year 2003.

Results - 2003

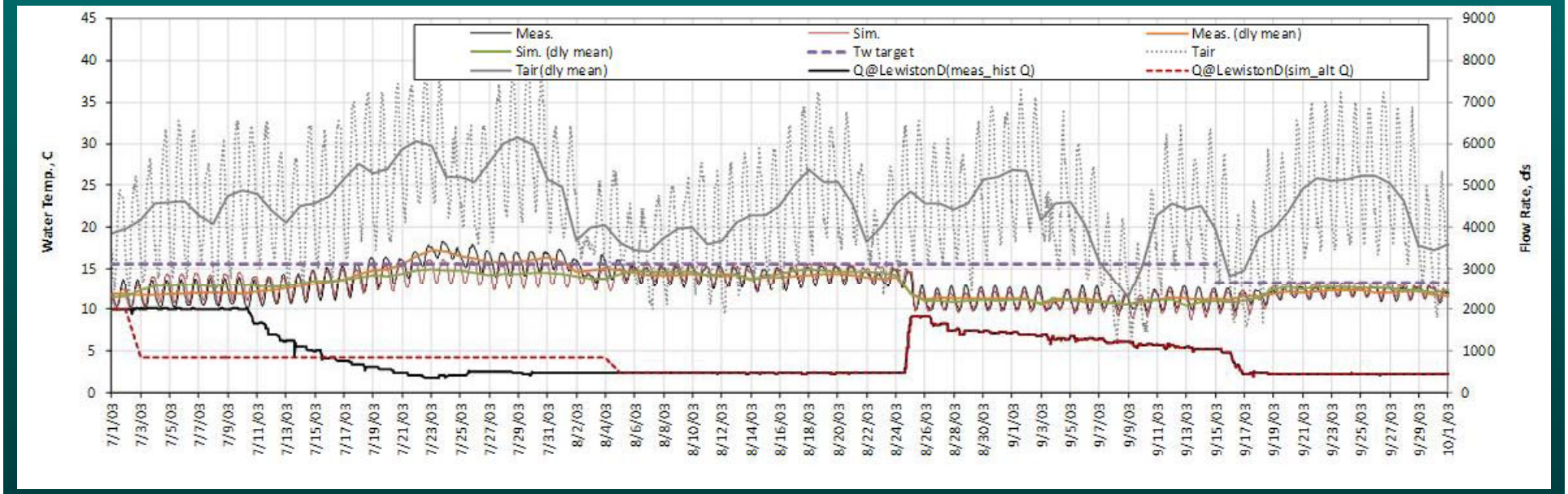


Figure 20. Scenario with the second alternative flow regime. Measured water temperature vs. Simulated water temperature, Measured flow rate vs. Simulated flow rate, Trinity River water temperature targets, air temperature. Year 2003.

Results - 2005

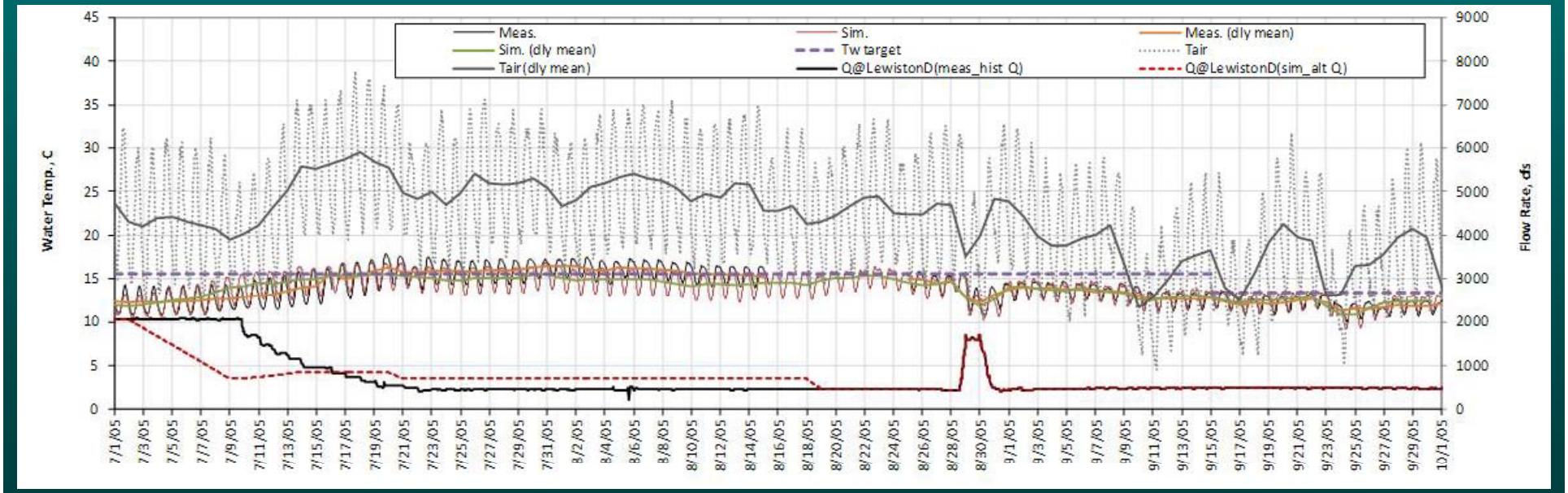


Figure 21. Scenario with the first alternative flow regime. Measured water temperature vs. Simulated water temperature, Measured flow rate vs. Simulated flow rate, Trinity River water temperature targets, air temperature. Year 2005.

Results - 2005

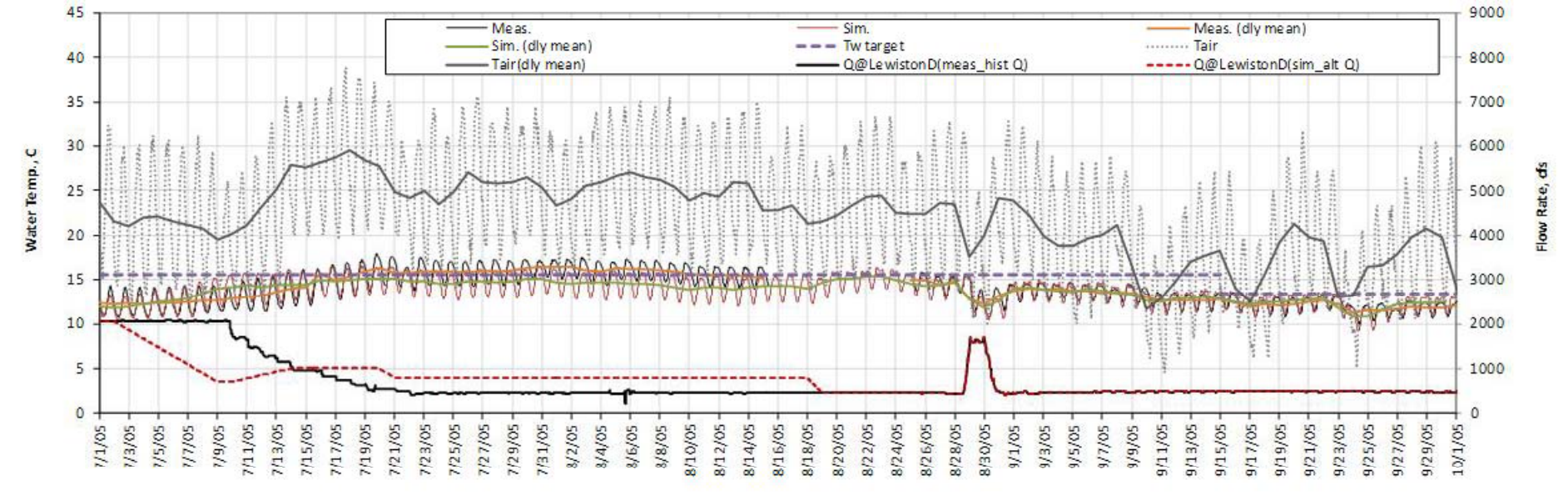


Figure 22. Scenario with the second alternative flow regime. Measured water temperature vs. Simulated water temperature, Measured flow rate vs. Simulated flow rate, Trinity River water temperature targets, air temperature. Year 2005.

Results – Alternative Flow Regimes 2003

Figure 23. Scenarios with the alternative flow regimes. Historic flow rate vs. alternative flow rates, volumes stored. Year 2003.

Results – Alternative Flow Regimes 2005

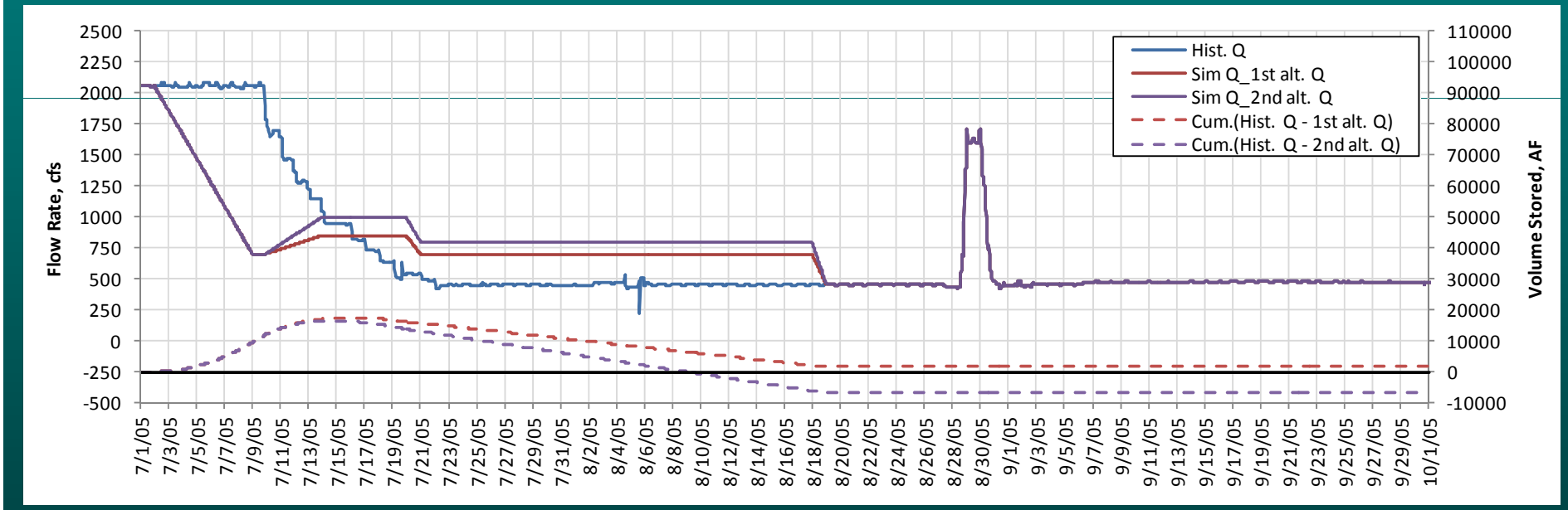


Figure 24. Scenarios with the alternative flow regimes. Historic flow rate vs. alternative flow rates, volumes stored. Year 2005.

Real-time Summer Temperature Management (Conclusions)

- Initial model results suggest that summer time releases may be managed to increase the certainty of meeting Trinity River water temperature targets set for the upper reach, Lewiston to Douglas City, in the period from July 1st through September 30th
- Reliable 5- or 10-day weather forecasts in the context of various meteorological conditions are essential in real-time flow operations
- Current facilities constraints, operational variations, and forecasting capability, will continue to provide challenges

Real-time Summer Temperature Management (Conclusions)

- The timing of the flow operations is essential. Considering the low base flow rate and adverse meteorology, any flow operation schedule to attempt to reserve ('bank') water starting after mid-July by decreasing flows below 450 cfs will be challenging due to (a) ability to reliably forecast weather conditions, and (b) lack of sufficient volume to reliably meet future needs for temperature management at Douglas City
- A more reliable approach is to reserve water in a period when it won't cause a temperature exceedance for release at a time when it could prevent an exceedance

Real-time Summer Temperature Management (cont.)

- Next Steps
  - Develop alternative spring/summer operational scenarios
  - Implement one or more alternatives as a ‘paper’ exercise in WY2013 & ‘14
  - Work with Forest Service to adapt/utilize their weather forecasts
  - Coordinate with potential SRTTG/USBR analyses of Whiskeytown/Clear Creek temperatures

Historical Temperature Target Performance

- Concept
  - What is the historical frequency, duration, and magnitude of temperature exceedances at DGC and NFH?
- Analysis
  - 1993-2011
  - DGC & NFH

Historical Temperature Target Performance (Analysis)

- There are three reporting periods since 1993 under consideration -
  - Pre-ROD (1993-2000)
  - Partial ROD (2001-2004)
  - Full ROD (2005-2011)
- The two compliance points are -
  - DGC
  - NFH

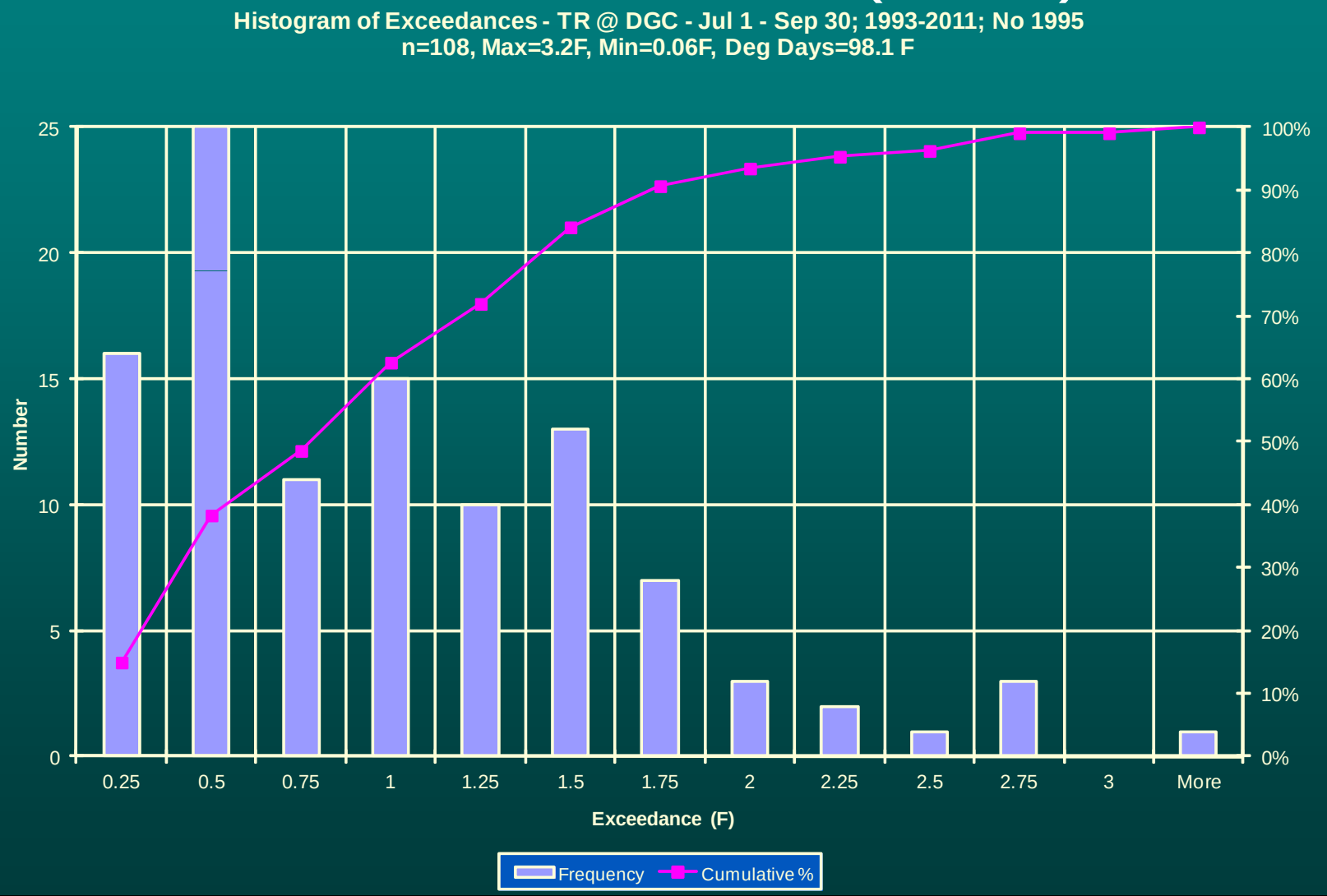
Historical Temperature Target Performance (DGC)

- Results

Table 1. Temperature (Fahrenheit) Target Exceedance Summary – Trinity River@Douglas City (DGC).

All WY1993-WY2011	Pre-ROD WY1993-WY2000	Part-ROD WY2001-WY2004	Full-ROD WY2005-WY2011
n=108	n=22	n=11	n=75
Degree-Days=98.1	Degree-Days=27.9	Degree-Days=14.6	Degree-Days=55.7
Max Exceed=3.2	Max Exceed=2.9	Max Exceed=3.2	Max Exceed=1.8
Min Exceed=0.06	Min Exceed=0.08	Min Exceed=0.15	Min Exceed=0.06
Consec Days=29	Consec Days=16	Consec Days=11	Consec Days=29
$Mean_{CD}$=0.74	$Mean_{CD}$ =1.27	$Mean_{CD}$ =1.32	$Mean_{CD}$ =0.74

Historical Temperature Target Performance (DGC)

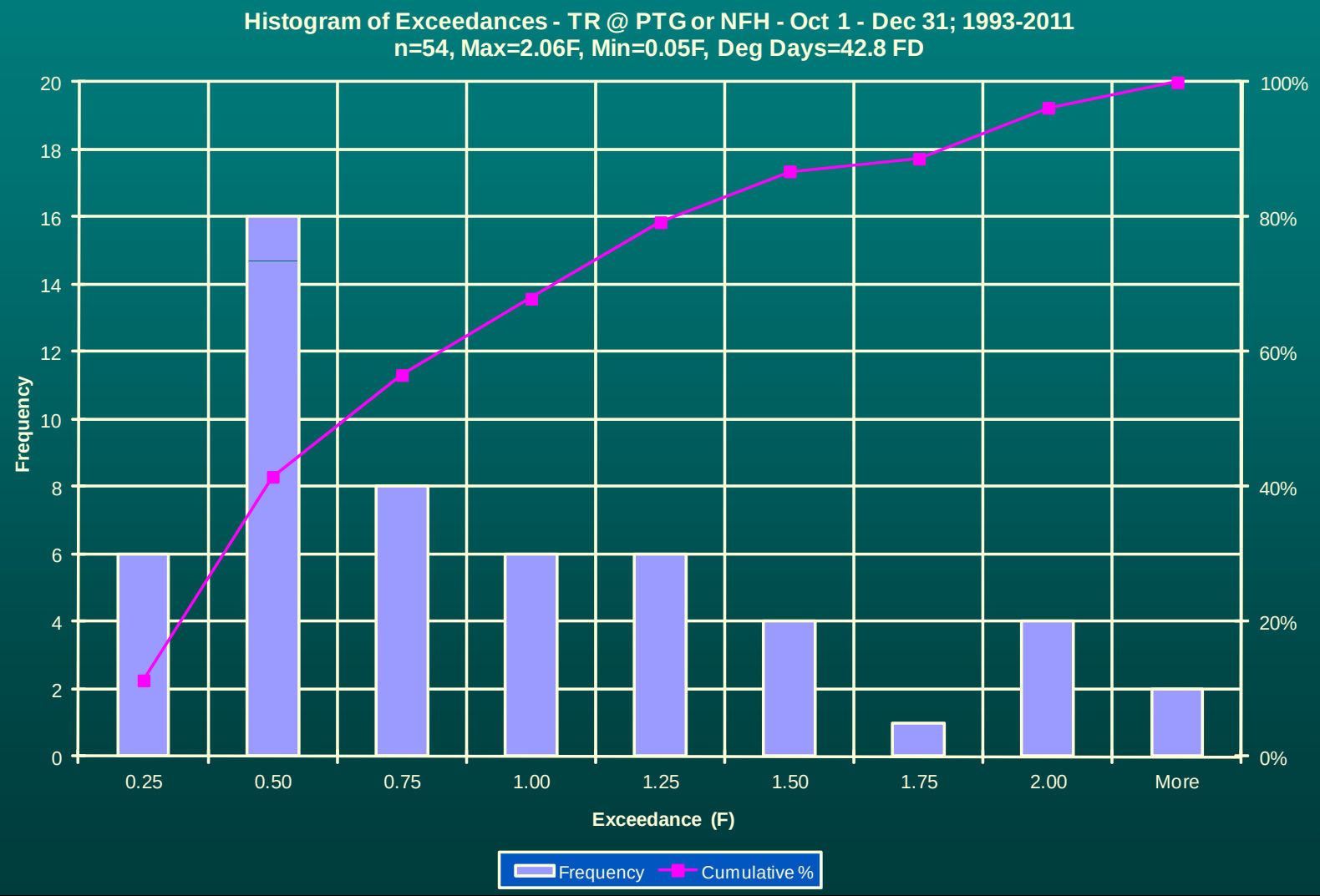


Historical Temperature Target Performance (NFH)

Table 1. Temperature (Fahrenheit) Target Exceedance Summary – Trinity River@North Fork (NFH).

All WY1993-WY2011	Pre-ROD WY1993-WY2000	Part-ROD WY2001-WY2004	Full-ROD WY2005-WY2011
n=54 Degree-Days=42.8 Max Exceed=2.06 Min Exceed=0.05 Consec Days=7 $Mean_{CD}$ =0.85	n=24 Degree-Days=20.5 Max Exceed=2.03 Min Exceed=0.05 Consec Days=7 $Mean_{CD}$ =0.85	n=12 Degree-Days=7.6 Max Exceed=1.35 Min Exceed=0.10 Consec Days=3 $Mean_{CD}$ =0.64	n=18 Degree-Days=14.7 Max Exceed=2.06 Min Exceed=0.06 Consec Days=4 $Mean_{CD}$ =0.82

Historical Temperature Target Performance (NFH)



Historical Temperature Target Performance (cont.)

- Conclusions
  - In general, the record of mean-daily temperature and other flow-related target performance is very good. Since full implementation of the ROD in WY2005, Reclamation met or bettered summer temperature targets more than 94% of the target (July 1-Dec 31) period. And, when not met, the temperature targets were exceeded by less than 1.8°F (1°C) 90% of that time.

Historical Temperature Target Performance (cont.)

- Next Steps
  - Add Weitchpec to the analysis
  - Reframe analysis to include air temperature effects on river heating
  - Examine potential water savings by inducing diurnal temperature fluctuations coincident with power peaking
  - Fish work group could analyze impacts of exceedances on fishes