IOP Workshop
Modeling Update

Columbus, GA

December 13, 2006

Topics

- Model Settings
- RPM3 Concepts
- RMP3 Modeling Results

Model Settings

- Water Control Plan enhanced with minimum flow requirements of ACF Interim Operating Plan

Model Settings

- Demands
  - Hydropower
    - Schedule based most recent operation
  - Water Supply
    - 2001 actual net for Chattahoochee and Flint Basins
    - 1993 actual net for Apalachicola River
  - Agricultural
    - Flint River provided by FWS STELLA modeling
    - Chattahoochee and Apalachicola 2000 projected
  - Required Flow
    - Atlanta
    - Columbus
    - Jim Woodruff Outflow; spawn and non-spawning season
- Operation
  - Balanced 4 federal reservoirs
  - Based on Comp Study Black & White model (Water Control Plan)
  - Down Ramping Rate Restriction

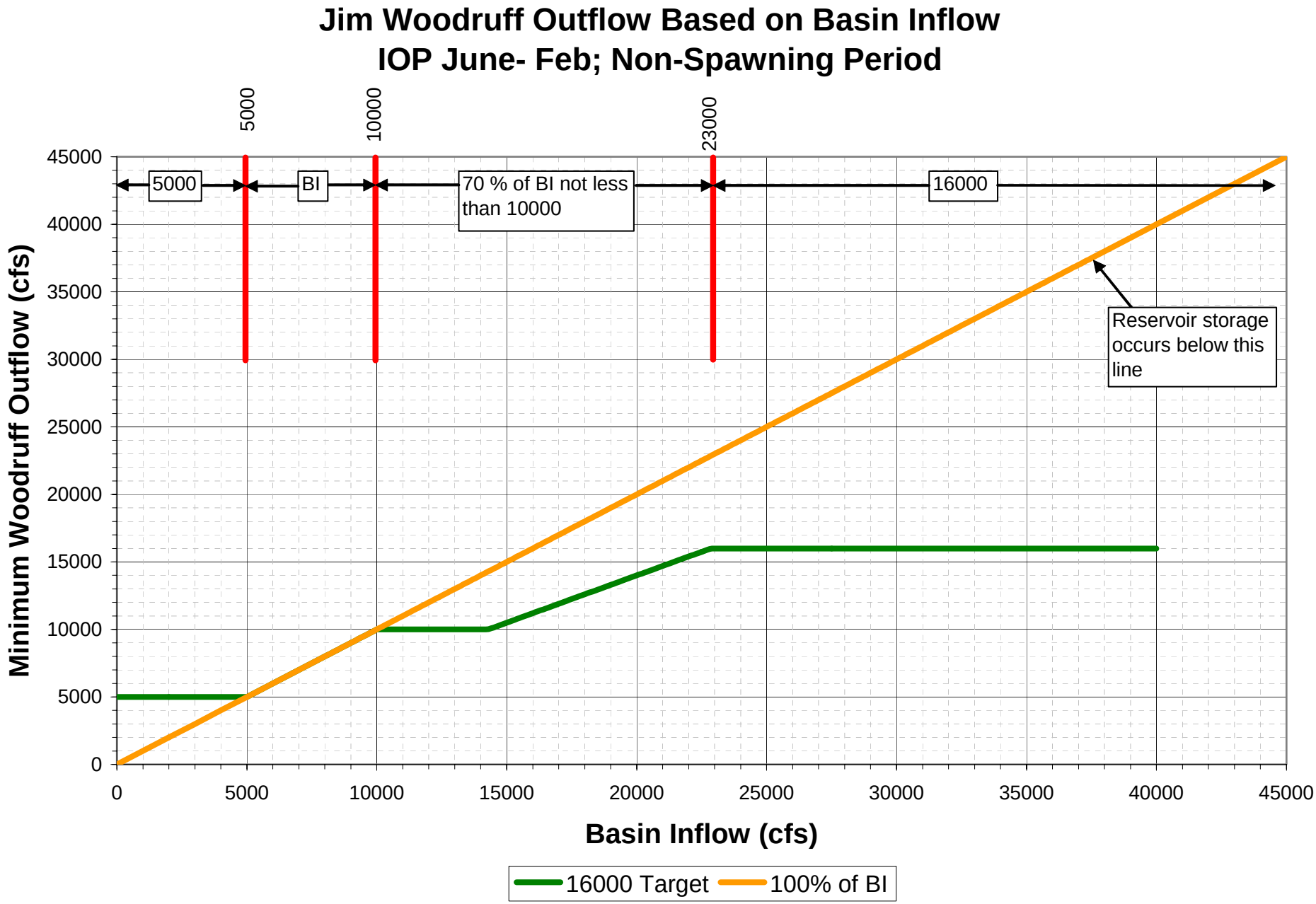
Hydropower Demand

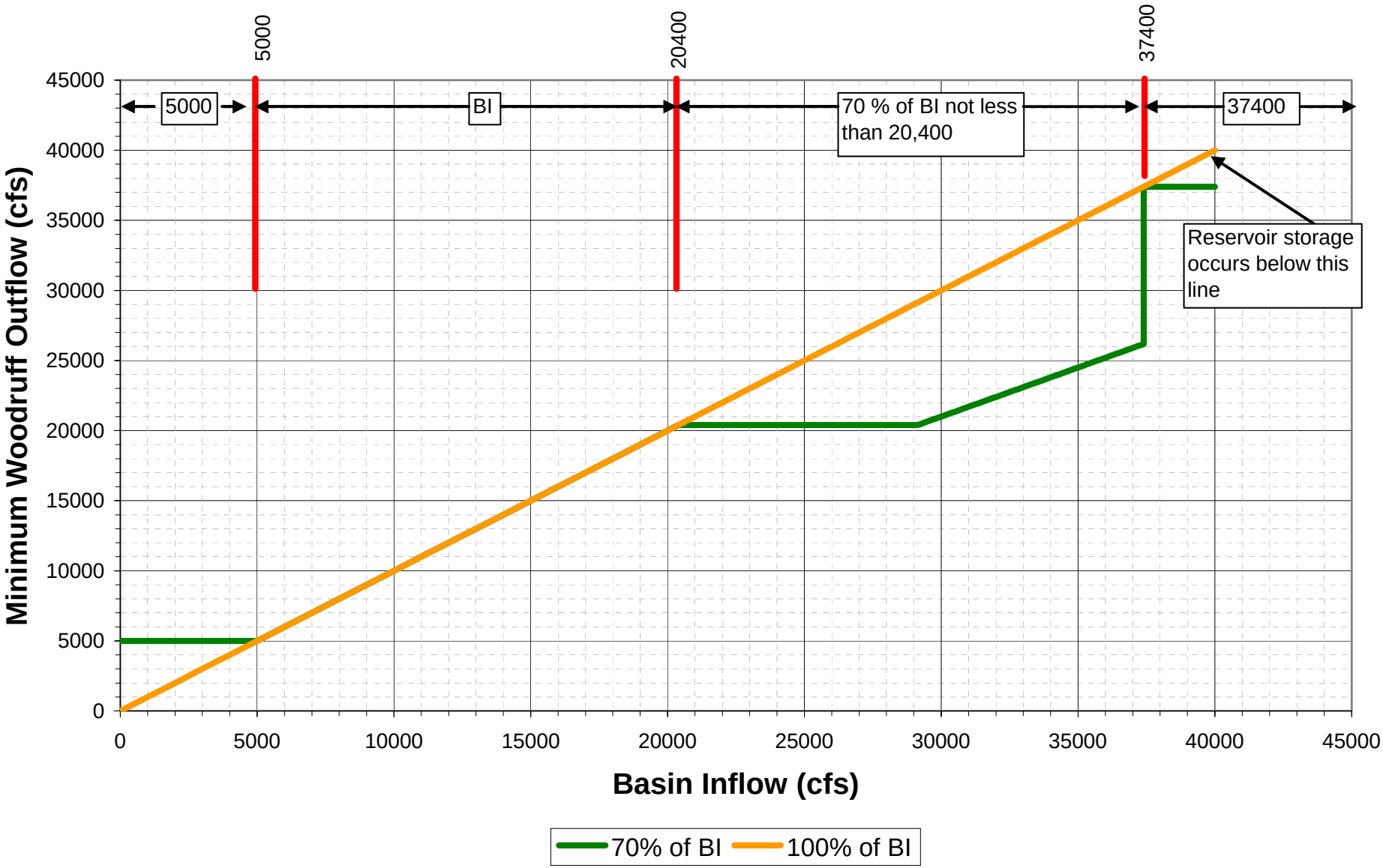
- Hydropower demand is a function of available storage. As the storage diminishes the demand reduces. Storage Zones described in the ACF Water Control manual dated 1989 used as the bases to assign the hydropower demand. Values developed from examining hydropower generation over the last few years.

IOP Model	Buford	West Point	WF George
Zone	(hours use)	(hours use)	(hours use)
1	3	4	4
2	2	2	2
3	2	2	2
4	0	0	0

Current IOP Minimum Flow Table

Months	Basin Inflow (BI) (cfs)	Releases from JWLD (cfs)
March - May (Spawning Period)	>= 37,400 >= 20,400 and < 37,400 < 20,400	not less than 37,400 >= 70% BI; not less than 20,400 >= BI; not less than 5,000
June - February (Non-Spawning Period)	>= 23,000 >=10,000 and < 23,000 < 10,000	not less than 16,000 >= 70% BI; not less than 10,000 >= BI; not less than 5,000

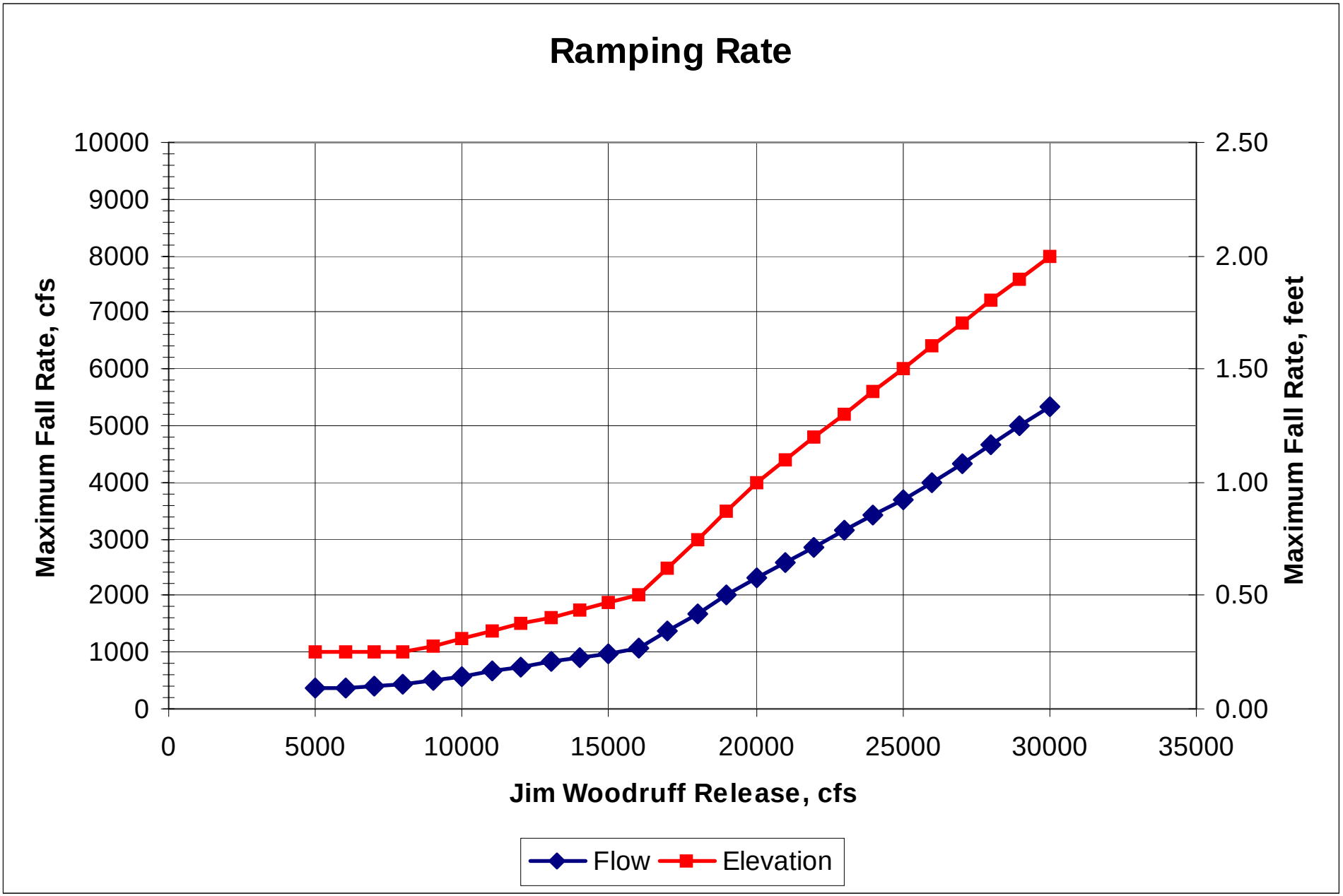

Jim Woodruff Outflow Based on Basin Inflow
IOP June- Feb; Non-Spawning Period
5000
10000
23000
5000
BI
70 % of BI not less than 10000
16000
Reservoir storage occurs below this line
Minimum Woodruff Outflow (cfs)
Basin Inflow (cfs)
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
16000 Target
100% of BI


Jim Woodruff Outflow Based on Basin Inflow
IOP March-May; Spawning Period
5000
20400
37400
5000
BI
70 % of BI not less than 20,400
37400
Reservoir storage occurs below this line
Minimum Woodruff Outflow (cfs)
Basin Inflow (cfs)
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
70% of BI
100% of BI

IOP Ramping Rate

Release Range		Maximum Fall Rate (ft/day), measured at Chattahoochee gage
Flows greater than 30,000 cfs*		No ramping restriction**
Flows greater than 20,000 cfs but <= 30,000*		1.0 to 2.0 ft/day
Exceeds Powerhouse Capacity (~16,000 cfs) but <= 20,000 cfs*		0.5 to 1.0 ft/day
Within Powerhouse Capacity and > 8,000 cfs*		0.25 to 0.5 ft/day
Within Powerhouse Capacity and <=8,000 cfs*		0.25 ft/day or less

IOP Graphic Ramping Rate

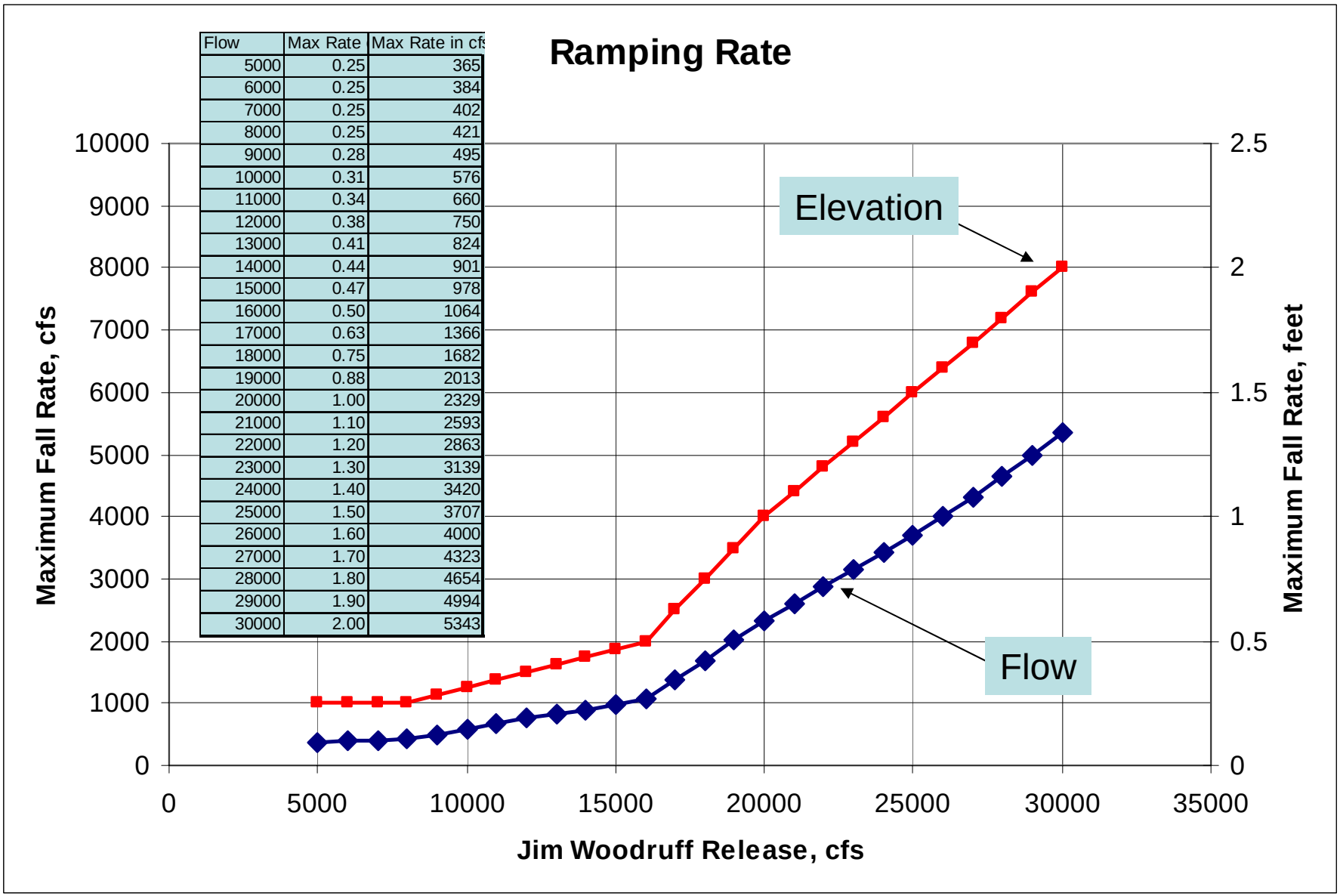


Down Ramping Rates

Release Range	Maximum Fall Rate (ft/day) measurse at Chattahoocee
> 30,000	none
> 20,000 and <= 30,000	1.0 to 2.0
> 16,000 and <= 20,000	0.5 to 1.0
> 8,000 and <= 16,000	0.25 to 0.5
<= 8,000	0.25

Maximum Fall Rate in Model

Flow	Max Rate	Max Rate in cfs
5000	0.25	365
6000	0.25	384
7000	0.25	402
8000	0.25	421
9000	0.28	495
10000	0.31	576
11000	0.34	660
12000	0.38	750
13000	0.41	824
14000	0.44	901
15000	0.47	978
16000	0.50	1064
17000	0.63	1366
18000	0.75	1682
19000	0.88	2013
20000	1.00	2329
21000	1.10	2593
22000	1.20	2863
23000	1.30	3139
24000	1.40	3420
25000	1.50	3707
26000	1.60	4000
27000	1.70	4323
28000	1.80	4654
29000	1.90	4994
30000	2.00	5343



Topics

- Model Settings
- **RPM3 Concepts**
- RPM3 Modeling Results

RPM3 Provisions

- Identify conditions that allow supporting higher minimum flows
- Identify water management measures to implement when conditions reach the drought trigger
- Provide models if modification to IOP parameters for spawning period are adopted

RPM3 Modeling Ideas

1. Determine maximum low flow target
2. Provide higher minimum during non-spawning period by reducing spawning flow requirement
3. Composite Storage trigger
4. Increase allowable storage

RPM3 Modeling Concept 1

1. Determine maximum low flow target system can support
   - Increase 5000 to larger values
   - 6000, 6300, 6600, 8000

RPM3 Modeling Concept 2

2. Reduce the spawning period high flow values and increase low flow target
   - High target of 37,400 reduce to 25,000
   - Intermediate target of 20,400 reduce to 16,000
   - Increase 5000 to 5800, 6500 and 7000

RPM3 Modeling Concept 3

3. Use system composite storage as drought trigger for desired and required flow
   - Desired flow = 6500
   - Required flow = 5000
   - Trigger activated when system reaches Zone 3
   - Trigger deactivated when the system recovers to Zone 1

RPM3 Modeling Concept 4

4. Increase percent stored when Basin Inflow > 10,000 cfs
   - Change from 30 % to 50 % (Release 50% of basin inflow)
   - Includes composite storage trigger concept
     - Desired flow = 6500
     - Required flow = 5000
     - Trigger activated when system reaches Zone 3
     - Trigger deactivated when the system recovers to Zone 1

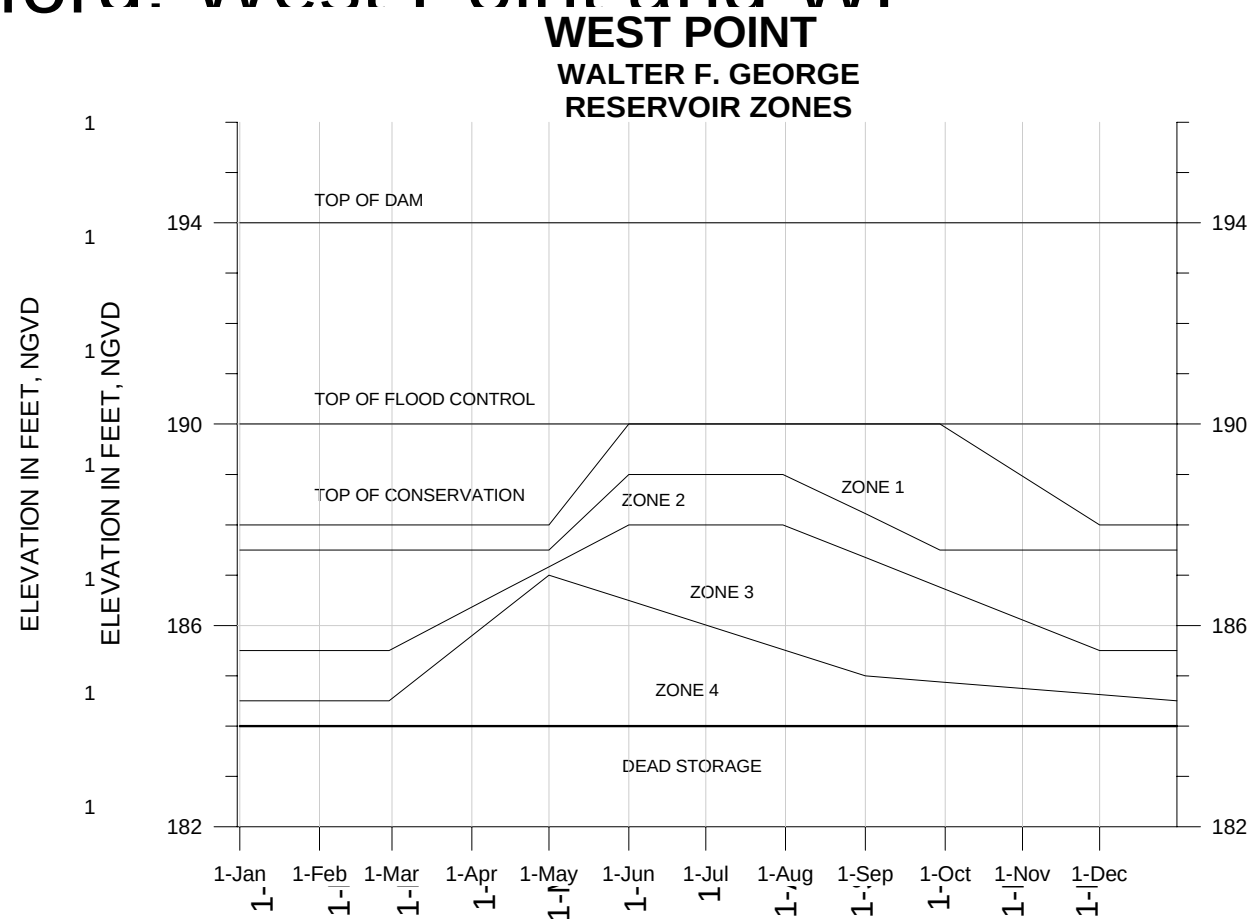
Selecting Low Flow Targets

- Based on characteristics of Jim Woodruff power plant
  - 5800 = running one unit at max capacity
  - 6500 = running two units at 7- 9 MW each
  - 7000 = no restriction from power plant, but habitat connectivity flow

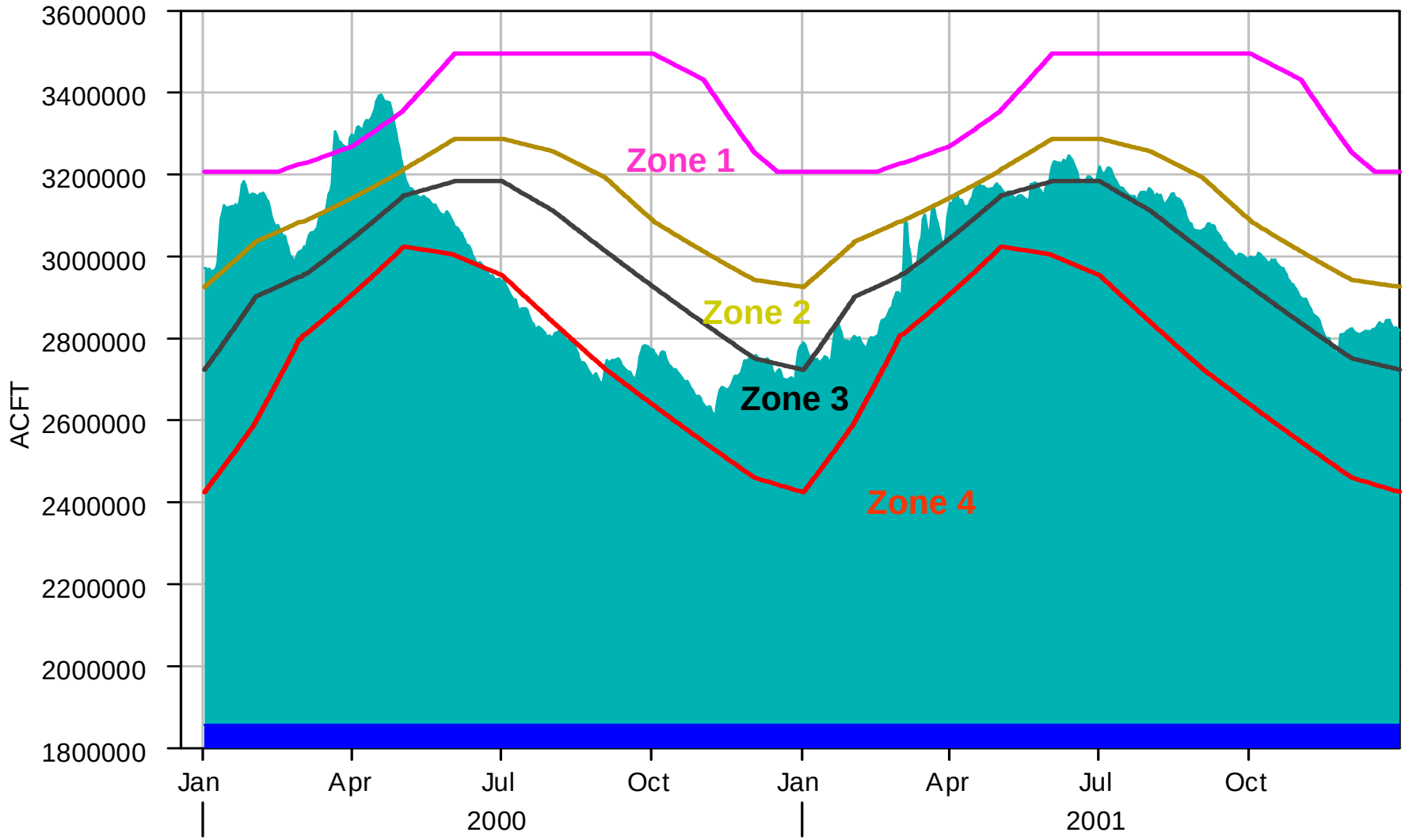
- Releasing 6000 requires running two units at low capacity and produces a high pitch sound throughout the power house creating a miserable work environment. Personnel are required to wear ear plugs and turn the volume all the way up of sound devices such as radios.

Composite Zones

- Summation of storage for each action zones at Buford, West Point and WF George



Composite Zones in AC-FT



Topics

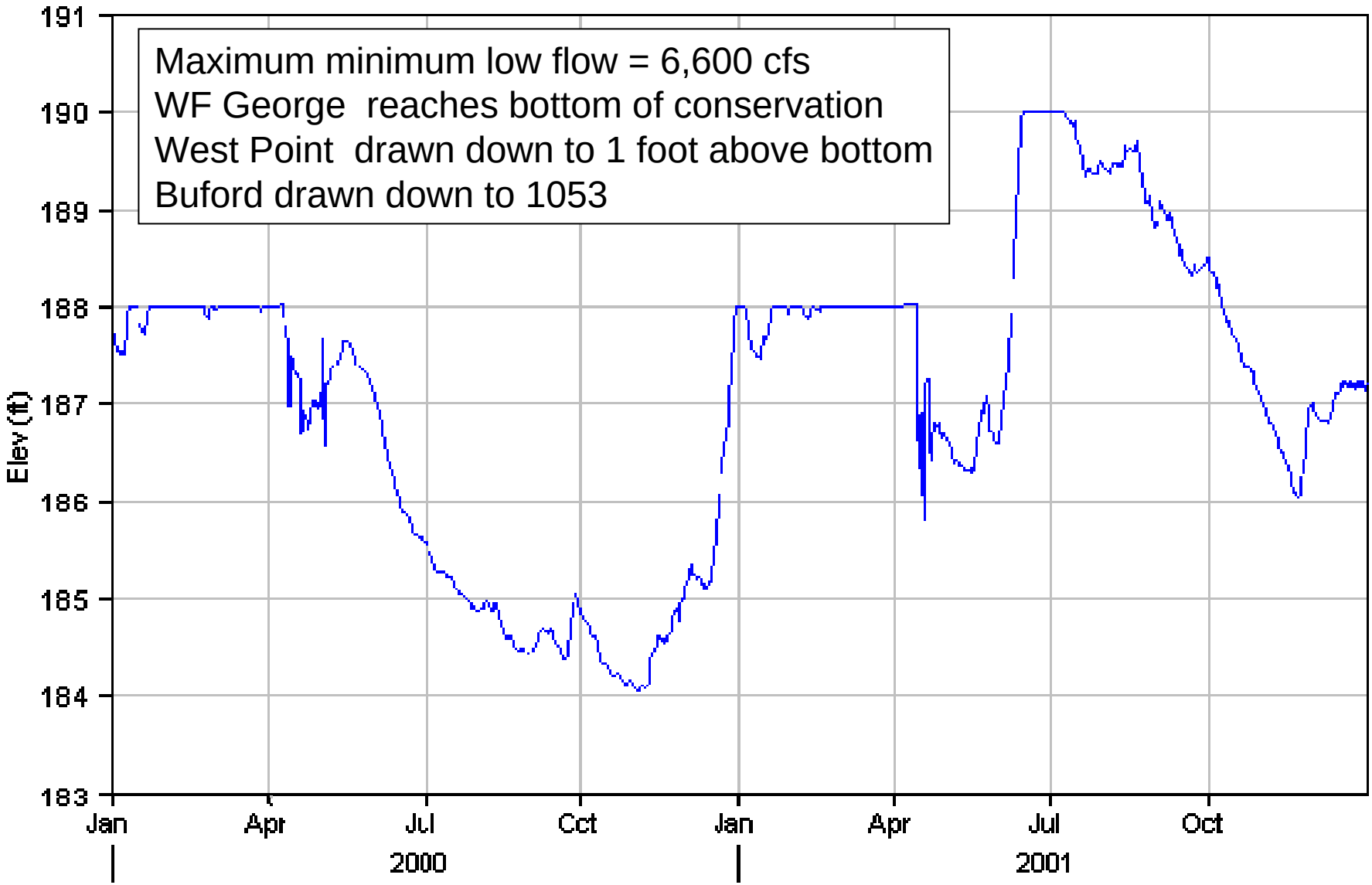
- Model Settings
- RPM3 Concepts
- **RPM3 Modeling Results**

Modeling Results Concept 1

Months	Basin Inflow (BI) (cfs)	Releases from JWLD (cfs)
March - May	>= 37,400	not less than 37,400
	>= 20,400 and < 37,400	>= 70% BI; not less than 20,400
	< 20,400	>= BI; not less than **6,600**
June - February	>= 23,000	not less than 16,000
	>=8,000 and < 23,000	>= 70% BI; not less than 8,000
	< 8,000	>= BI; not less than **6,600**

6,000 **6,300** **8,000**

Modeling Results Concept 1



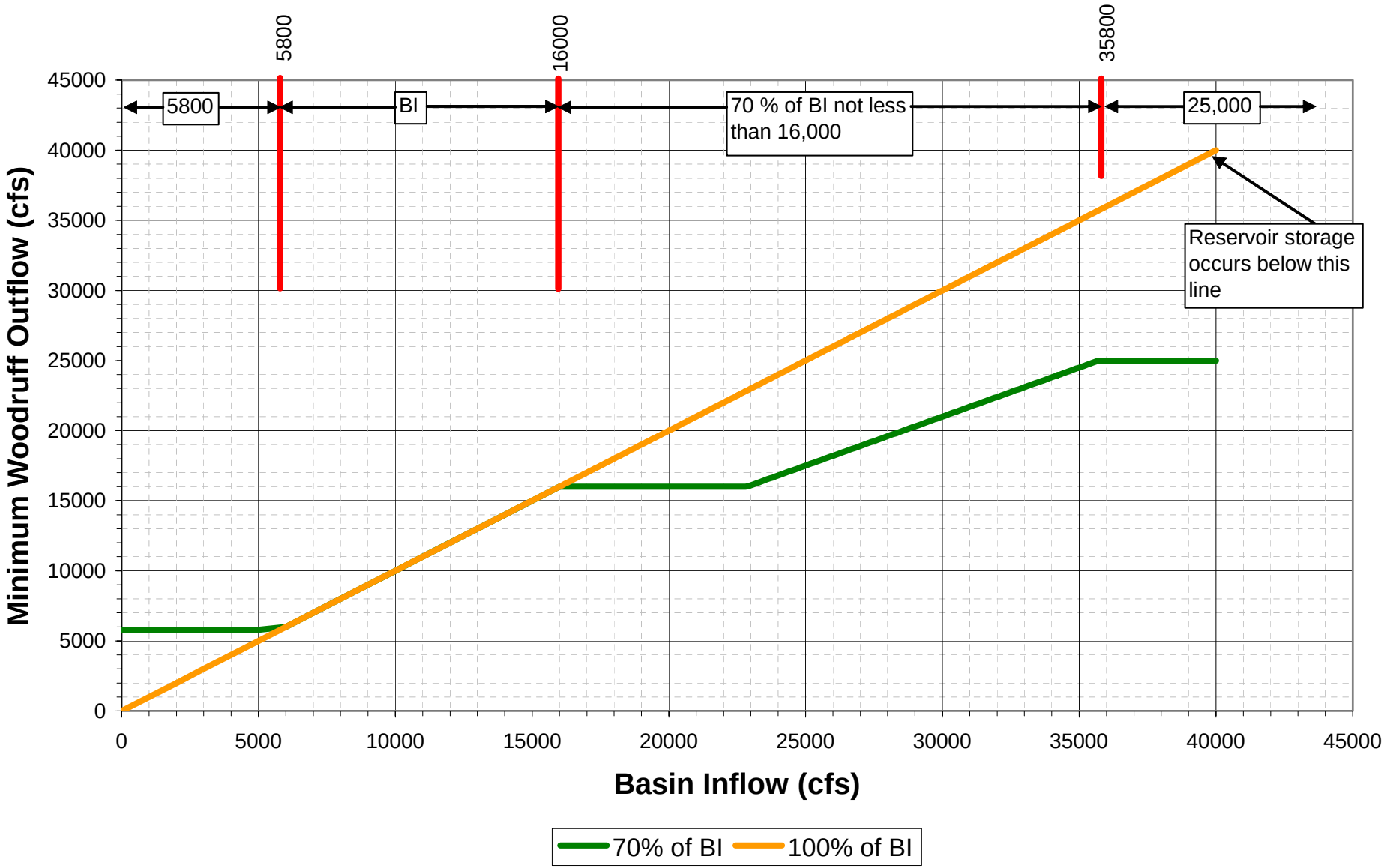
Computed July 2006

Modeling Results Concept 2

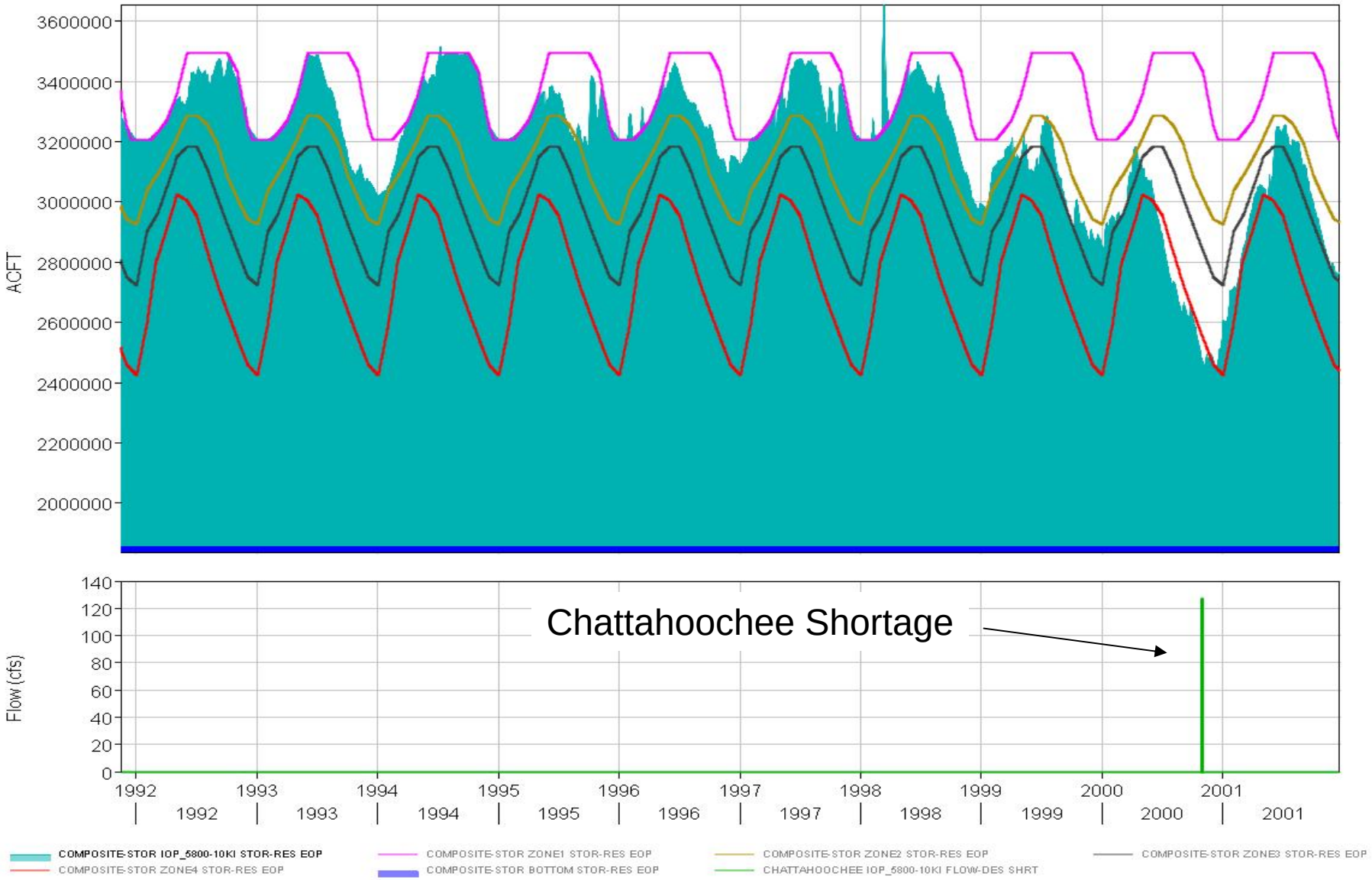
- Reduce the spawning period high flow values and increase low flow target
  - Reduce high flow from 37,400 to 25,000
  - Reduce Intermediate flow from 20,400 to 16,000
  - Increase 5000 to 5800, 6500 and 7000

Modeling Results Concept 2
Revised IOP Minimum Flow Table

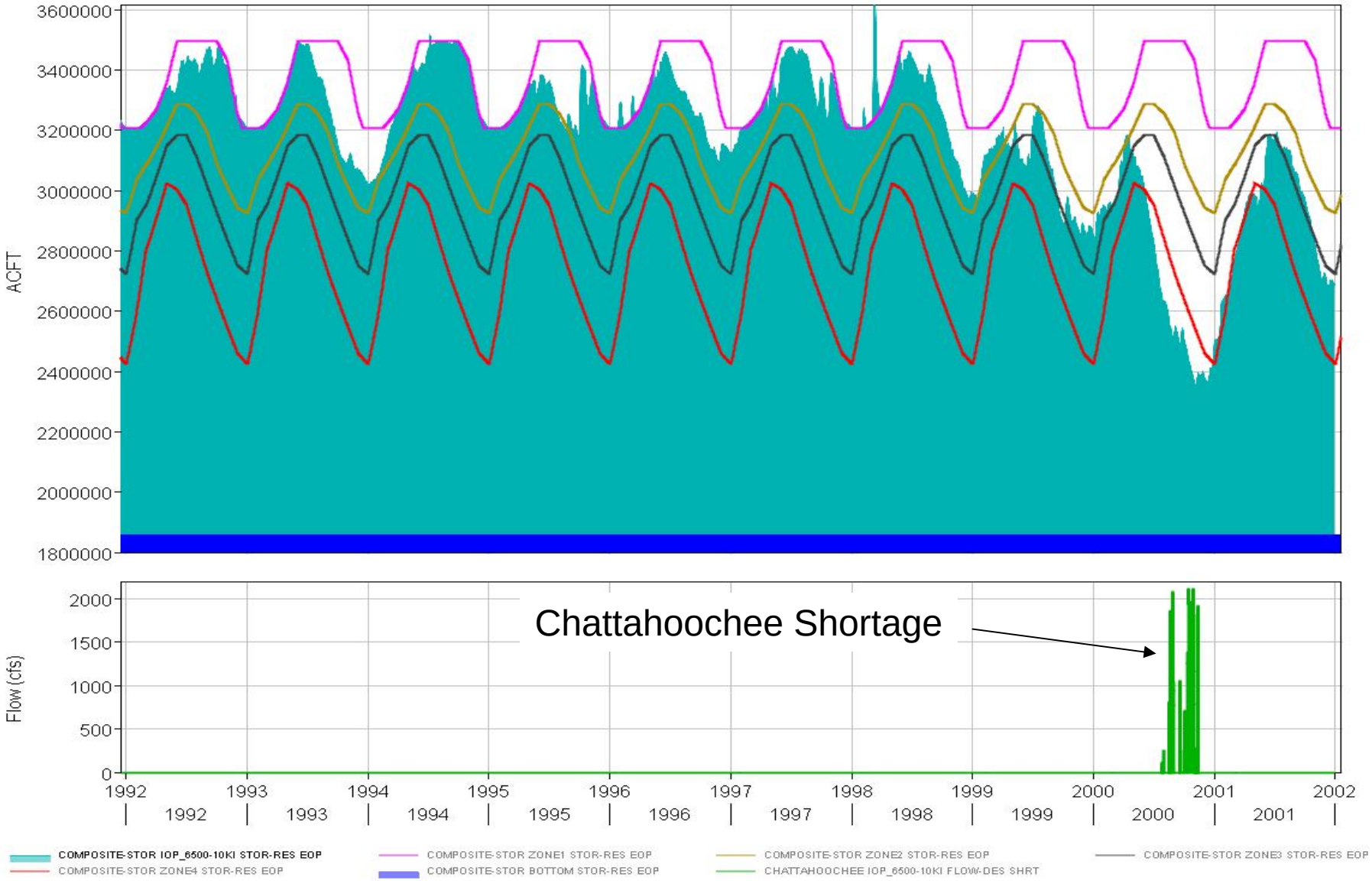
Months	Basin Inflow (BI) (cfs)	Releases from JWLD (cfs)
March - May	>= 35,800	not less than 25,000
	>= 16,000 and < 35,800	>= 70% BI; not less than 16,000
	< 16,000	>= BI; not less than 5,800
June - February	>= 23,000	not less than 16,000
	>=10,000 and < 23,000	>= 70% BI; not less than 10,000
	< 10,000	>= BI; not less than 5,800


Jim Woodruff Outflow Based on Basin Inflow
IOP March-May; Spawning Period; Revised Down
5800
16000
35800
5800
BI
70 % of BI not less than 16,000
25,000
Reservoir storage occurs below this line
Minimum Woodruff Outflow (cfs)
Basin Inflow (cfs)
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
70% of BI
100% of BI

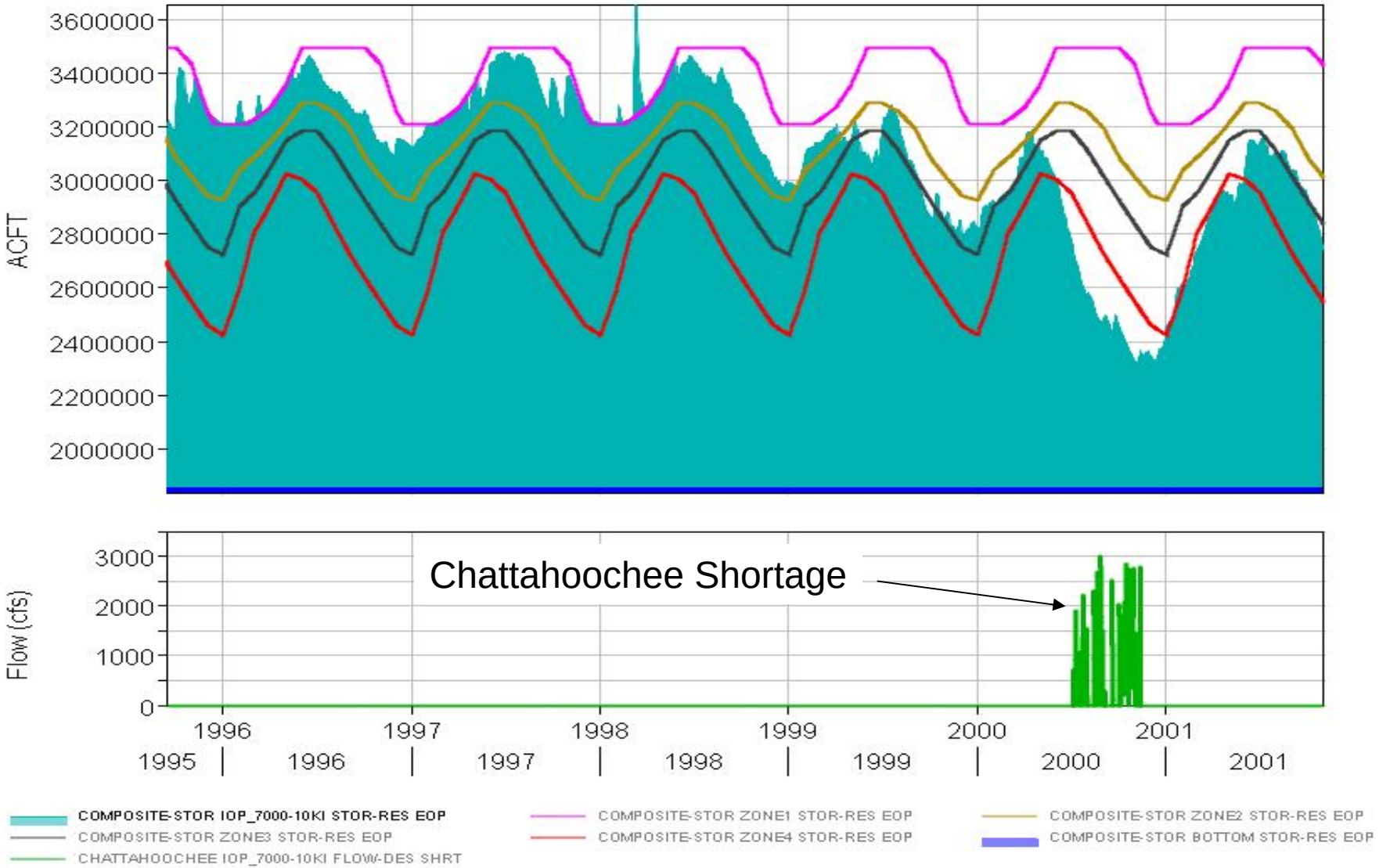
5800 Minimum Flow



6500 Minimum Flow



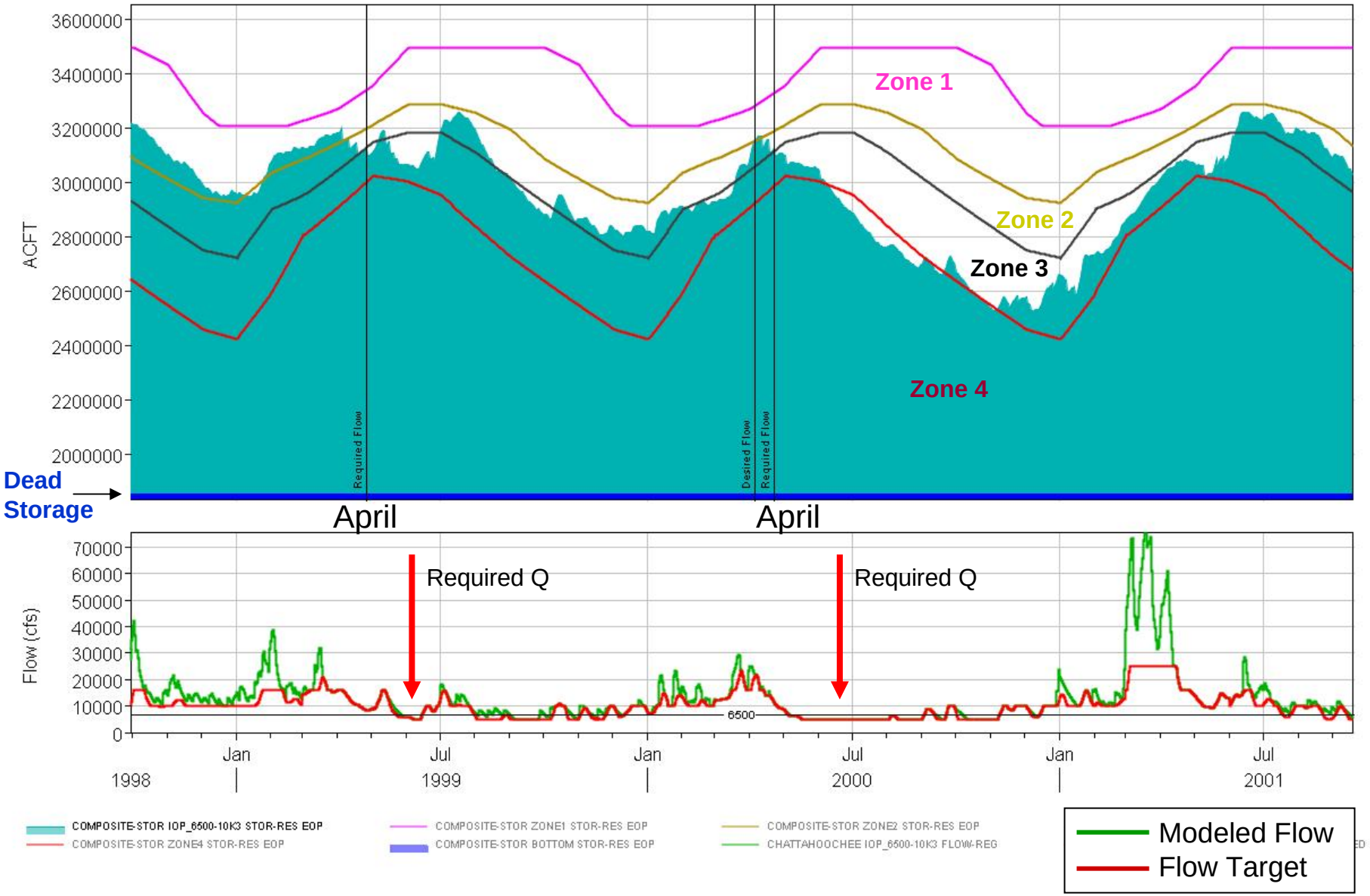
7000 Minimum Flow



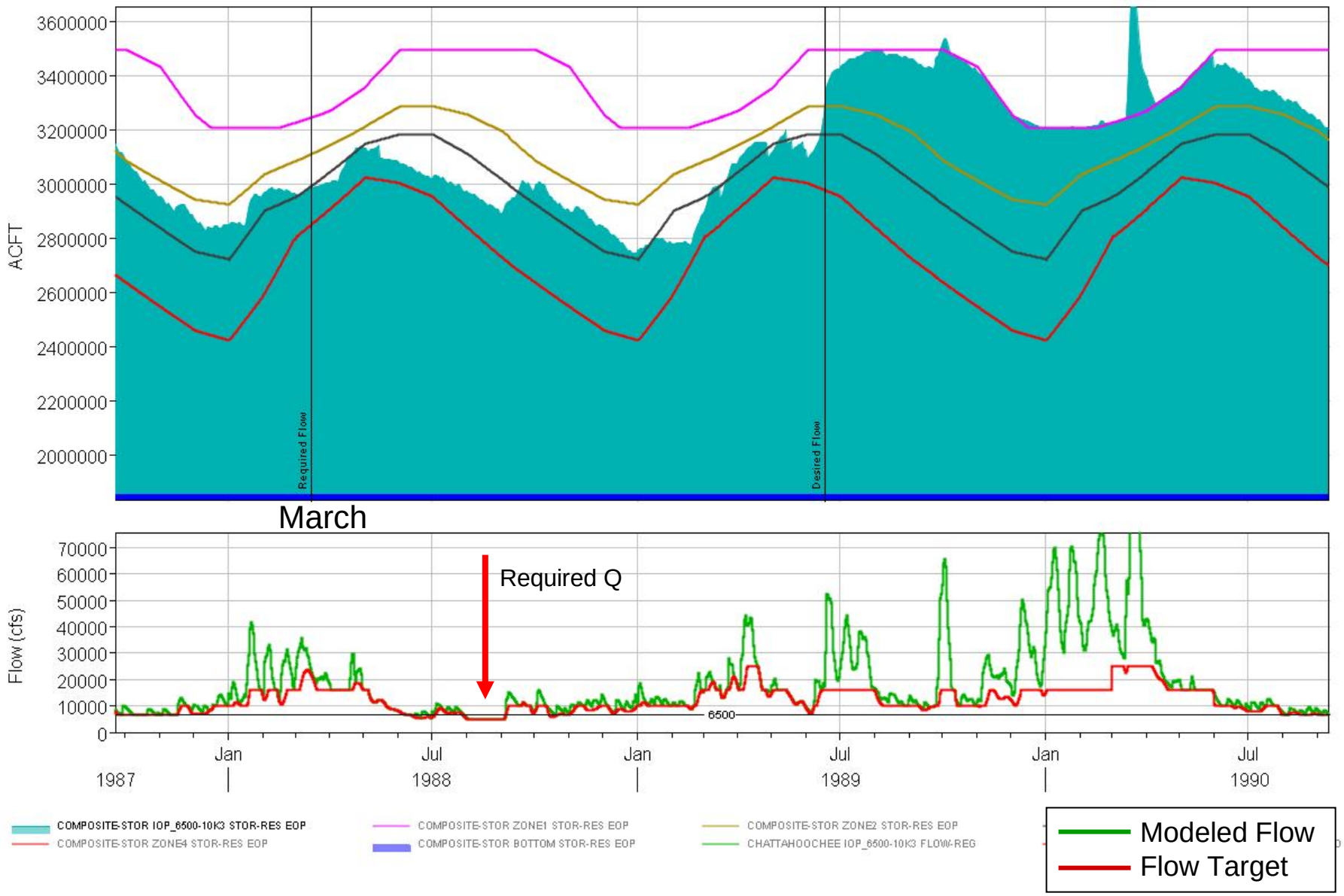
Modeling Results Concept 3

3. Use system composite storage as drought trigger for desired and required flow
   - Desired flow = 6500
   - Required flow = 5000
   - Trigger activated when system reaches Zone 3
   - Trigger deactivated when the system recovers to Zone 1

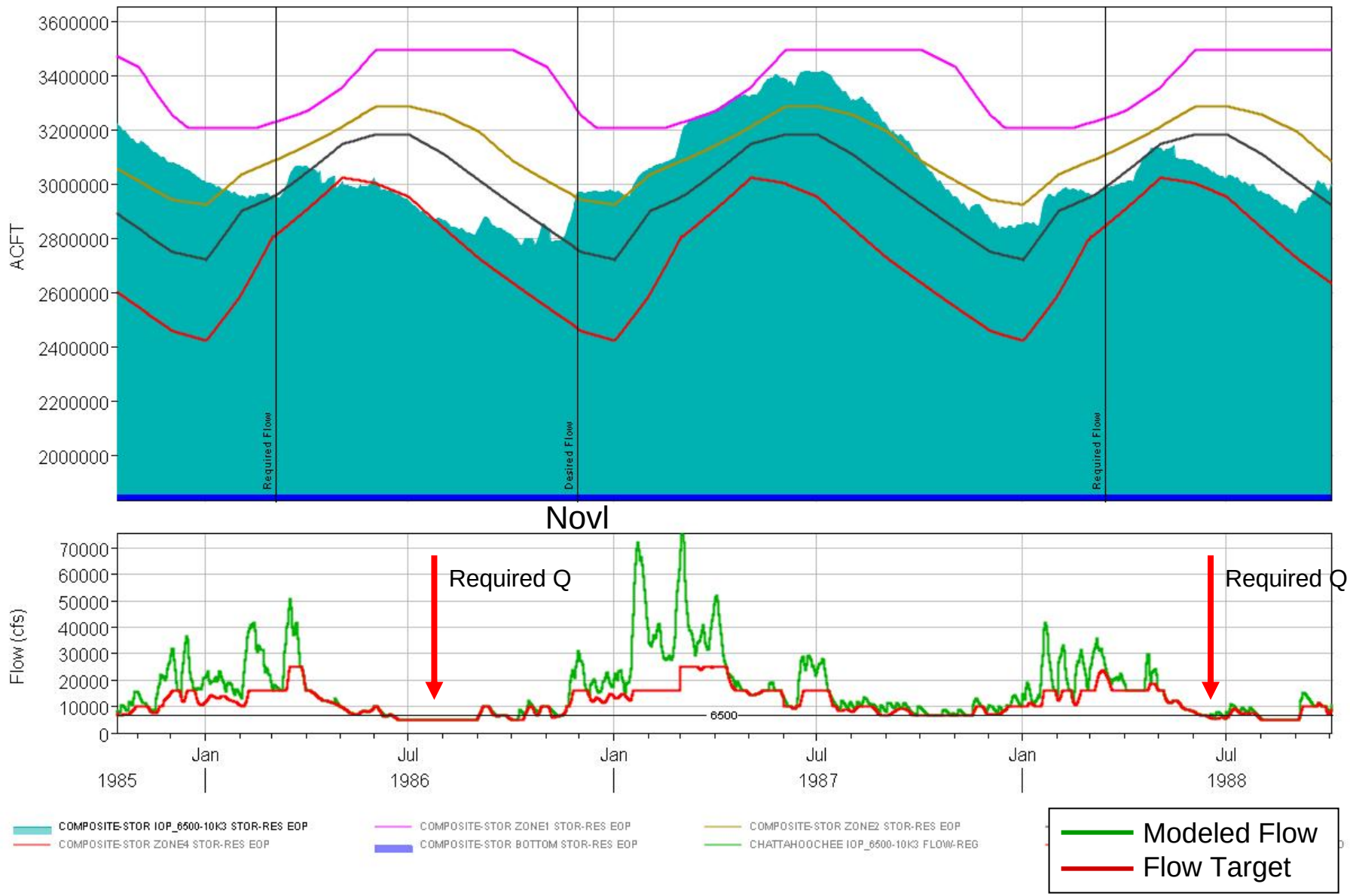
Composite Trigger 1999 & 2000



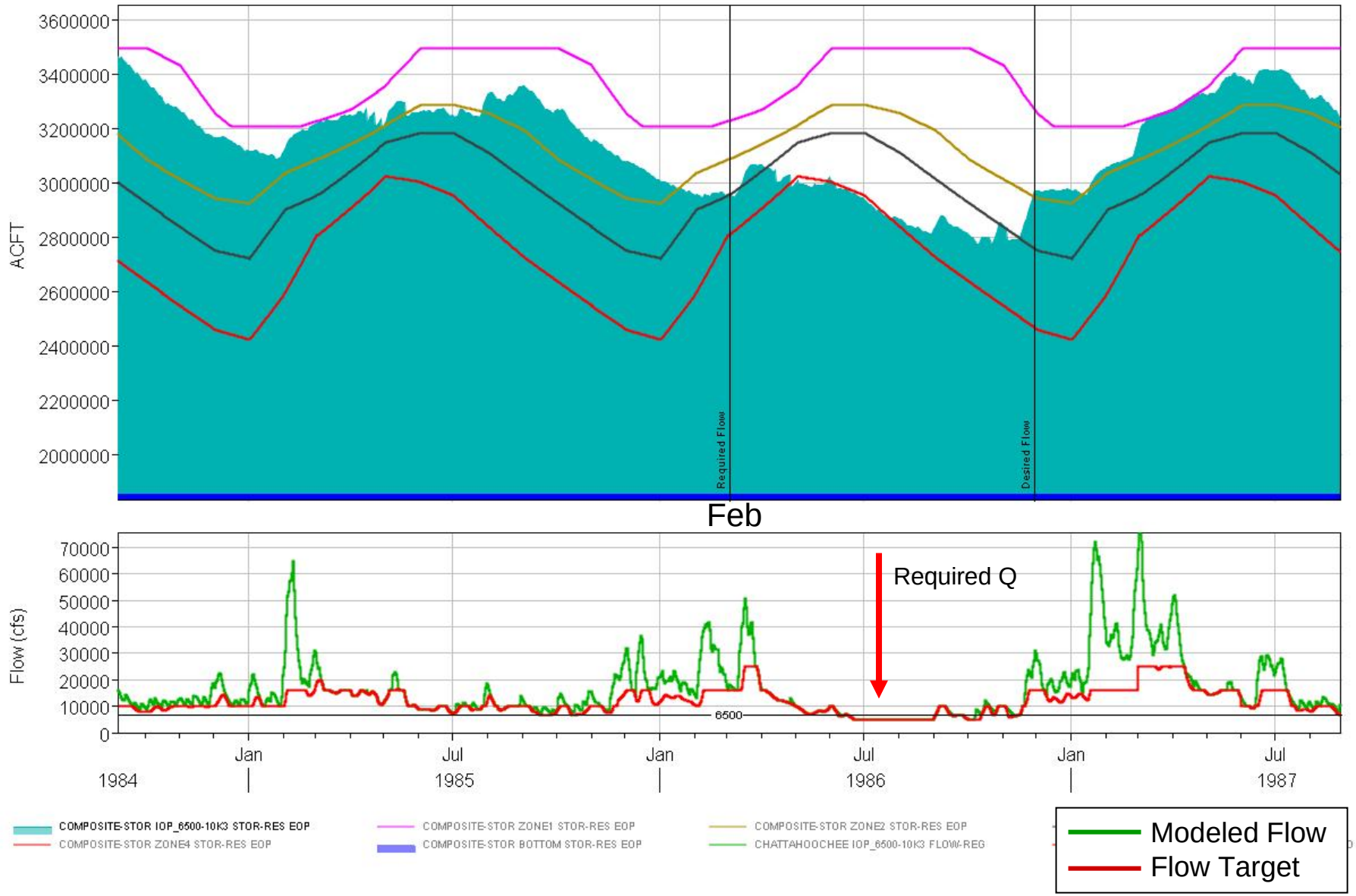
Composite Trigger 1988



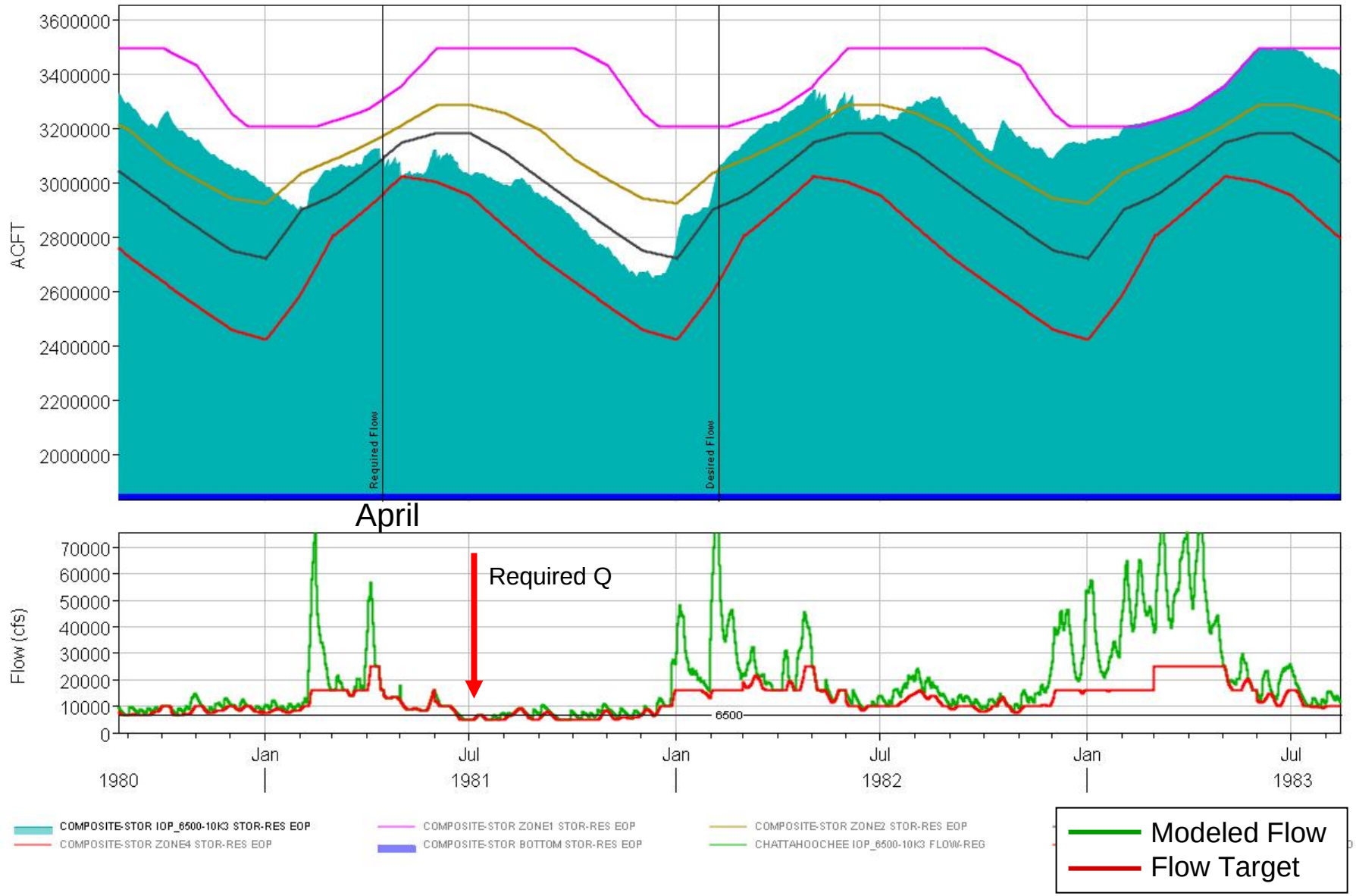
Composite Trigger 1987



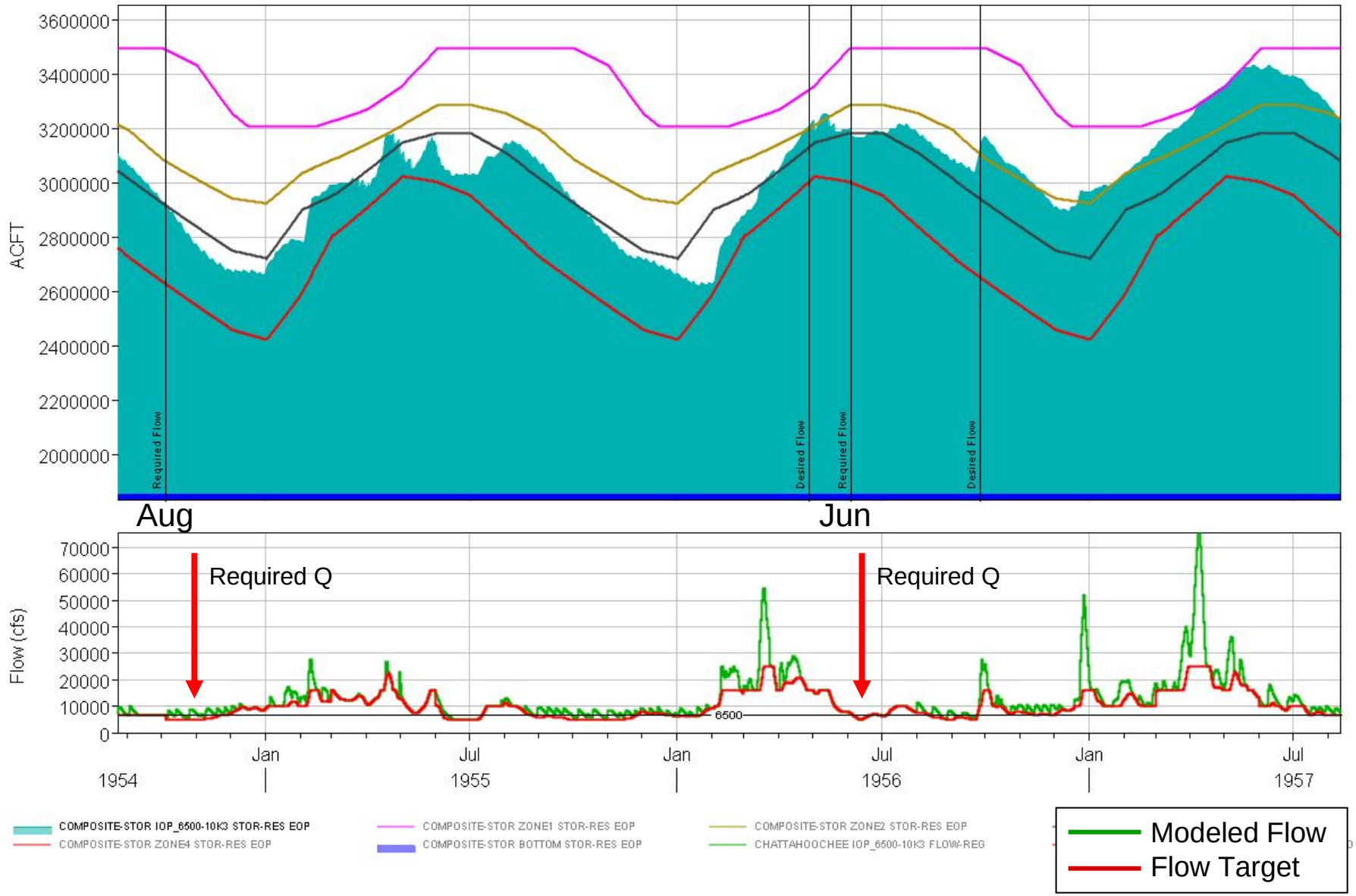
Composite Trigger 1986



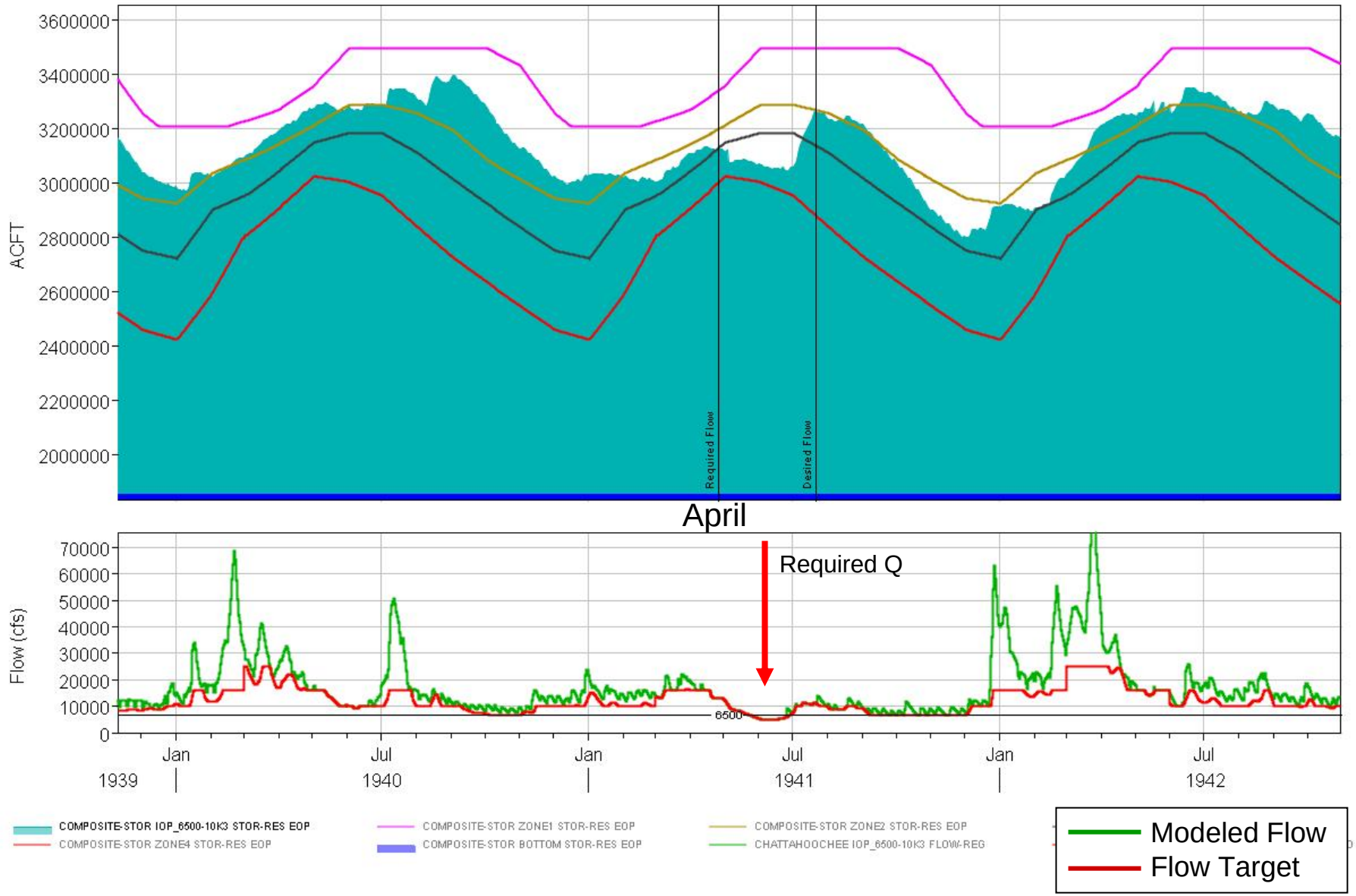
Composite Trigger 1981



Composite Trigger 1954 & 1956



Composite Trigger 1941



USGS
science for a changing world

Droughts in Georgia

Droughts do not have the immediate effects of floods, but sustained droughts can cause economic stress throughout the State. The word "drought" has various meanings, depending on a person's perspective. To a farmer, a drought is a period of moisture deficiency that affects the crops under cultivation—even two weeks without rainfall can stress many crops during certain periods of the growing cycle. To a meteorologist, a drought is a prolonged period when precipitation is less than normal. To a water manager, a drought is a deficiency in water supply that affects water availability and water quality. To a hydrologist, a drought is an extended period of decreased precipitation and streamflow. Droughts in Georgia have severely affected municipal and industrial water supplies, agriculture, stream water quality, recreation at major reservoirs, hydropower generation, navigation, and forest resources.

USGS streamflow gaging station, Ogeechee River near Eden, July 2000.

In Georgia, droughts have been documented at U.S. Geological Survey (USGS) streamflow gaging stations since the 1890's. From 1910 to 1940, about 20 streamflow gaging stations were in operation. Since the early 1950's through the late 1980's, about 100 streamflow gaging stations were in operation. Currently (2000), the USGS streamflow gaging network consists of more than 135 continuous-recording gages. Groundwater levels are currently monitored at 165 wells equipped with continuous recorders.

U.S. Department of the Interior
U.S. Geological Survey

Summary of previous droughts

The 1903–05 drought was the earliest recorded severe drought in Georgia. In 1904, the U.S. Weather Bureau (1904, p. 4) reported that levels in streams and wells were the lowest in several years. Many localities had to conserve water for stock and machinery and many factories were forced to close or operate at half capacity.

The drought of 1924–27 was most severe in the Altamaha, Chattahoochee, and Coosa River basins, and in north-central Georgia. The U.S. Weather Bureau (1925, p. 49–50) reported:

> The drought was especially severe during the latter part of July, August, and September and the rivers in many places reached the lowest stages ever known. The scarcity of water had a profound influence on industrial and agricultural conditions in Georgia.

The severity of the 1930–35 drought exceeded a 25-year recurrence interval in central and southwestern Georgia and affected much of the United States. In extreme northern and southeastern Georgia, the recurrence interval was 10–25 years; in coastal Georgia and the Savannah and Ogeechee River basins, however, the recurrence interval was less than 10 years. The **recurrence interval** is the average time between droughts of a given severity. In a drought with a 25-year recurrence interval, the low streamflows occur, on average, once every 25 years.

The 1938–44 drought affected much of the same area as the 1930–35 drought. In the upper Coosa and Chattahoochee River basins, the recurrence interval exceeded 50 years, and in much of central and southern Georgia, it exceeded 25 years. In the Savannah and Ogeechee River basins and in extreme northern and southwestern Georgia, the drought had recurrence intervals of 10–25 years.

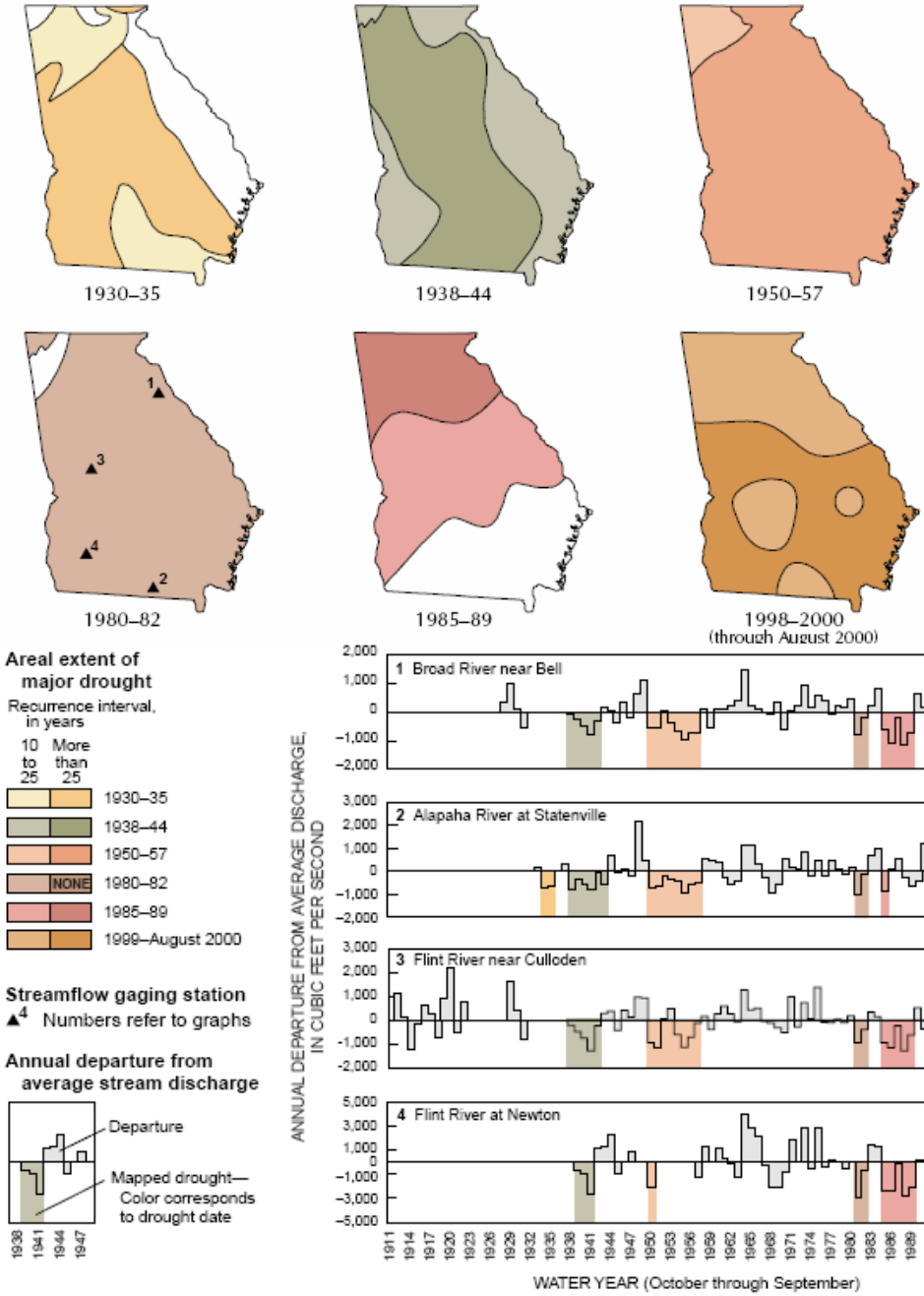
The 1950–57 drought was most severe in southern Georgia, with most streamflows having recurrence intervals exceeding 25 years. In northeastern Georgia, the drought severity also exceeded the 25-year recurrence interval. In northwestern Georgia, the recurrence interval of the drought was between 10 and 25 years.

Selected rivers in Georgia.

The 1980–82 drought resulted in the lowest streamflows since 1954 in most areas, and the lowest streamflows since 1925 in some areas (Carter, 1983, p. 2). Recurrence intervals of 10–25 years were common in most of Georgia. Pool levels at four major reservoirs receded to the lowest levels since first filling. Groundwater levels in many observation wells were lower than previously observed. Nearly continuous declines were recorded in some wells for as long as 20 consecutive months, and water levels remained below previous record lows for as long as nine consecutive months.

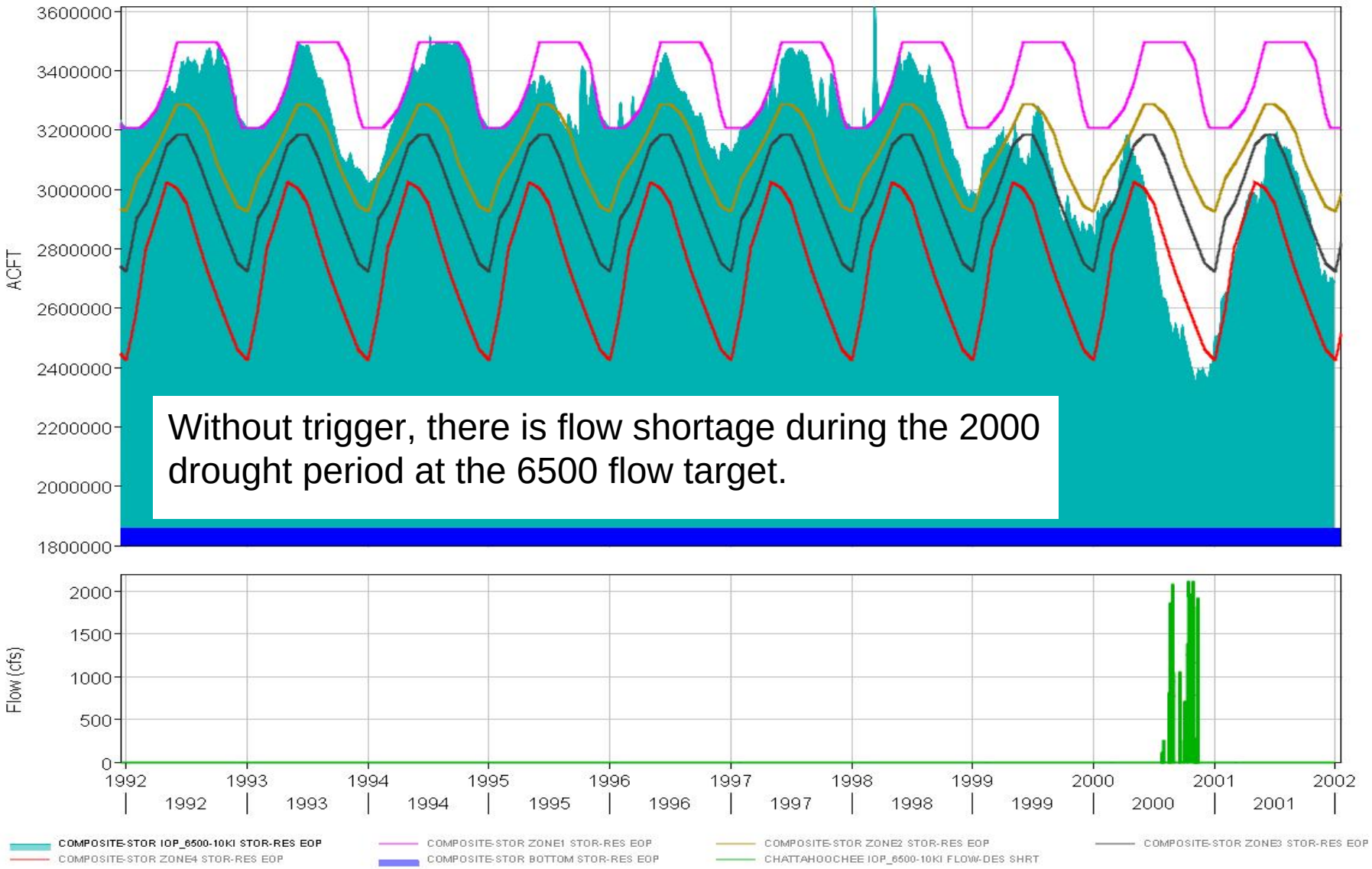
Streamflows during the 1985–89 drought in northern Georgia were near the lowest of the 1900's. By 1988, the drought had reached recurrence intervals of 50–100 years in extreme northern Georgia, 10–25 years in central Georgia, and less than 10 years in southern Georgia. Water-supply shortages occurred in Georgia in 1986. Shortages first occurred in a few Atlanta

U.S. Geological Open-File Report 00-380
October 2000



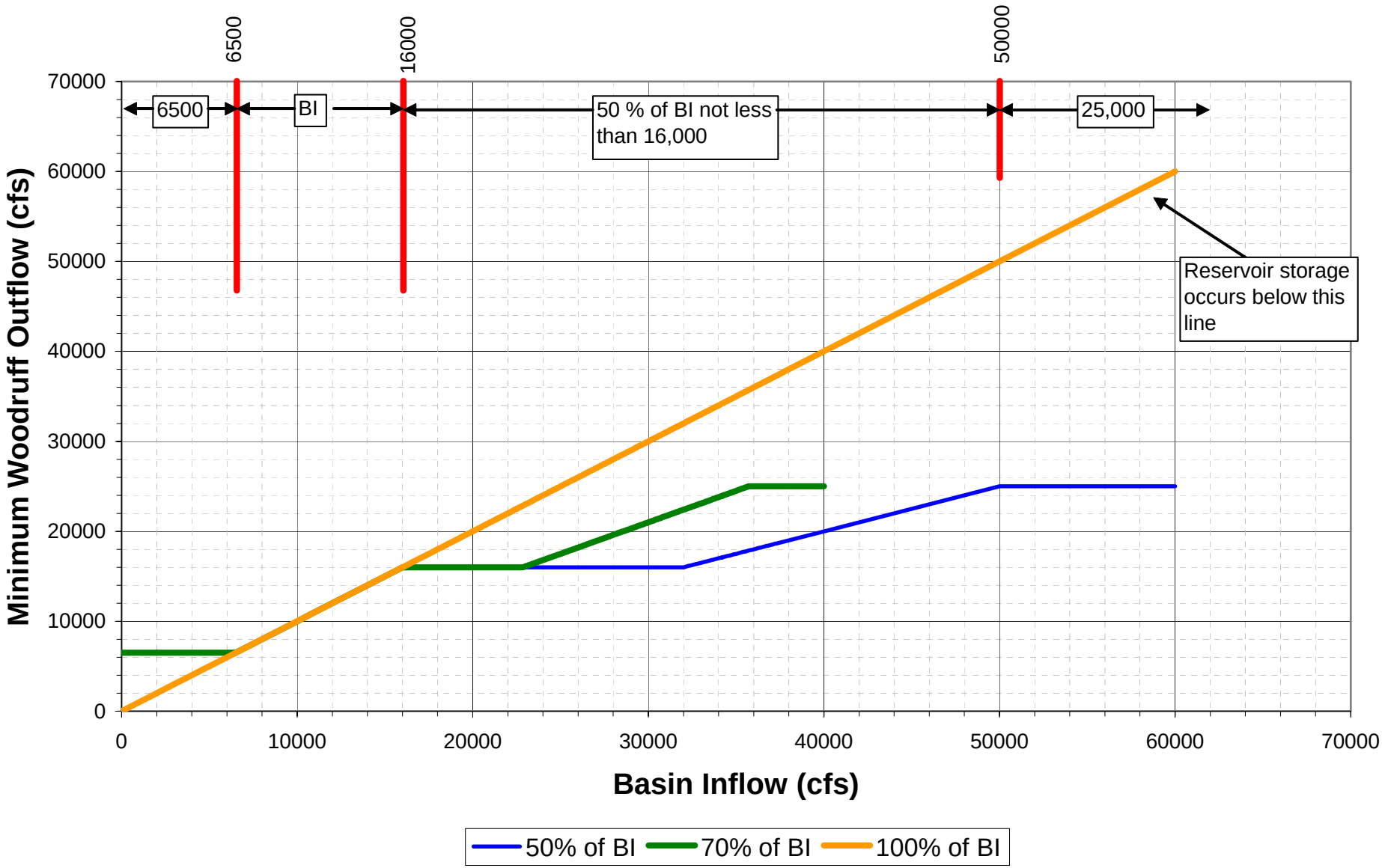
Areal extent of major droughts in Georgia, and annual departure from average stream discharge for selected sites, water years 1911–2000. (Source: Data from U.S. Geological Survey files. Water year 2000—average of monthly departures October 1999–August 2000.)

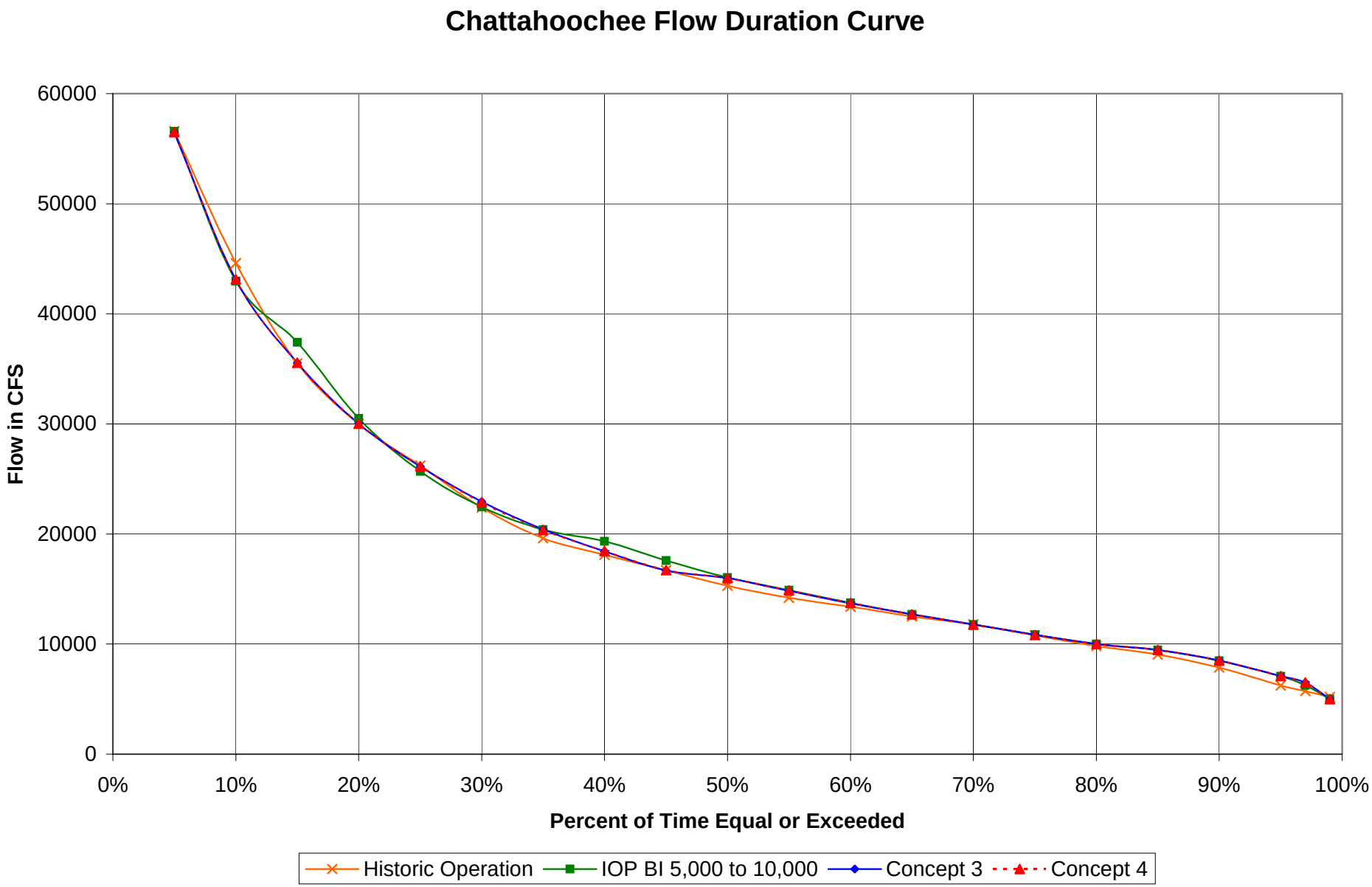
Shortage without Trigger



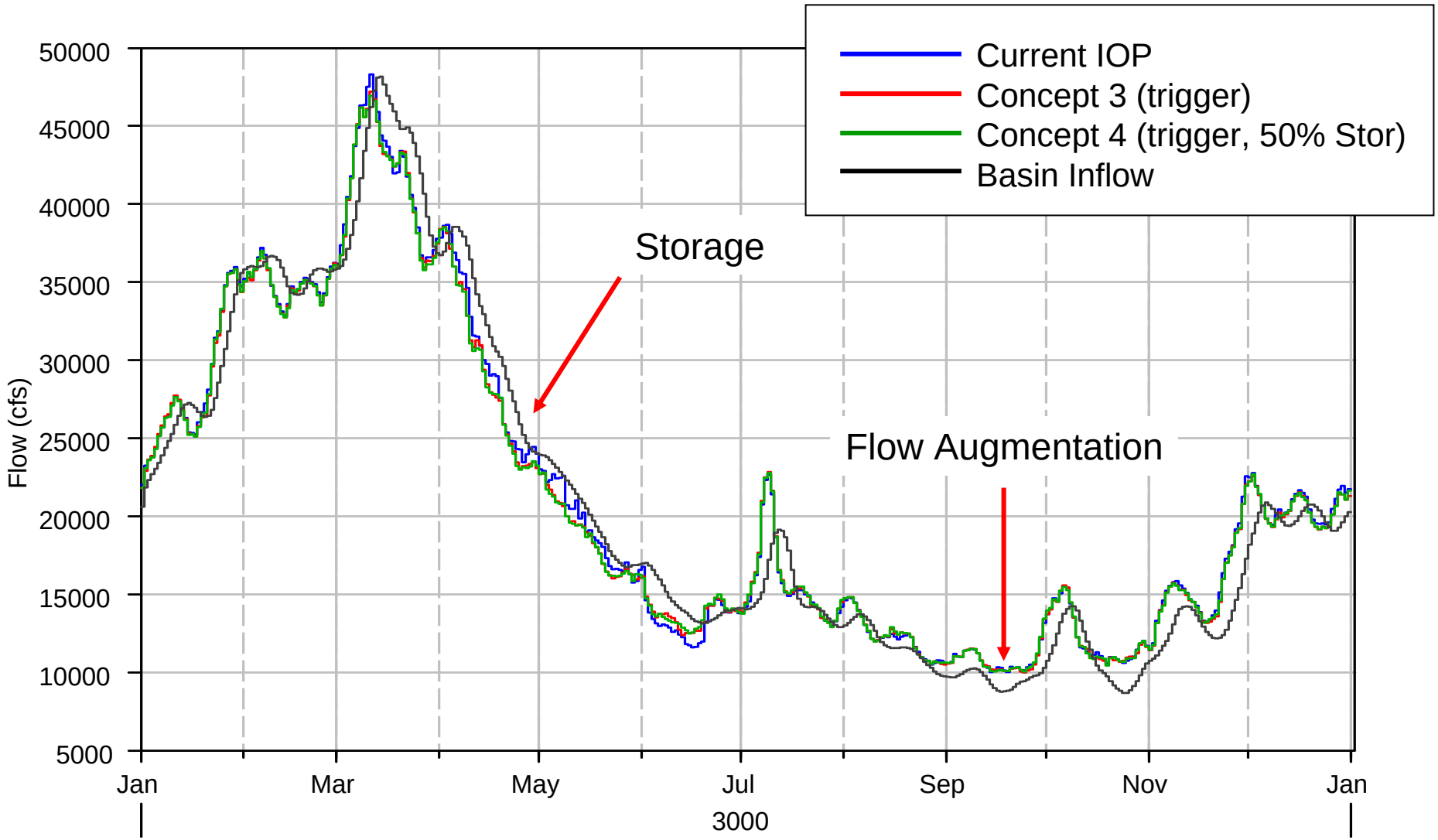
Modeling Results Concept 4

4. Increase percent stored when Basin Inflow > 10,000 cfs
   - Change from 30 % to 50 % (Release 50% of basin inflow)
   - Includes composite storage trigger concept
     - Desired flow = 6500
     - Required flow = 5000
     - Trigger activated when system reaches Zone 3
     - Trigger deactivated when the system recovers to Zone 1

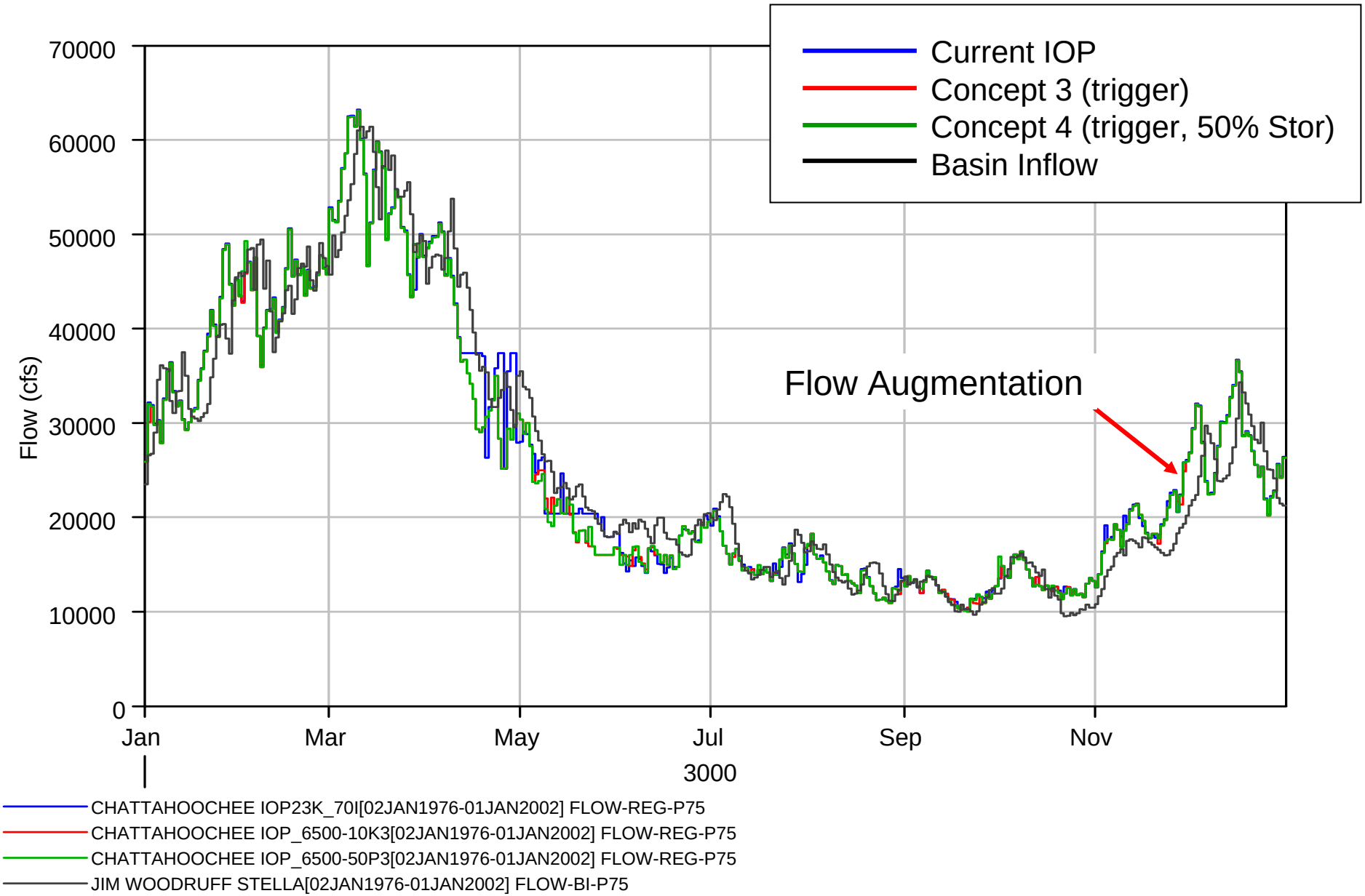

Jim Woodruff Outflow Based on Basin Inflow
IOP March-May; Spawning Period; Revised Down
6500
16000
50000
6500
BI
50 % of BI not less than 16,000
25,000
Reservoir storage occurs below this line
Minimum Woodruff Outflow (cfs)
Basin Inflow (cfs)
0
10000
20000
30000
40000
50000
60000
70000
50% of BI
70% of BI
100% of BI


Chattahoochee Flow Duration Curve
60000
50000
40000
30000
20000
10000
0
Flow in CFS
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equal or Exceeded
Historic Operation
IOP BI 5,000 to 10,000
Concept 3
Concept 4

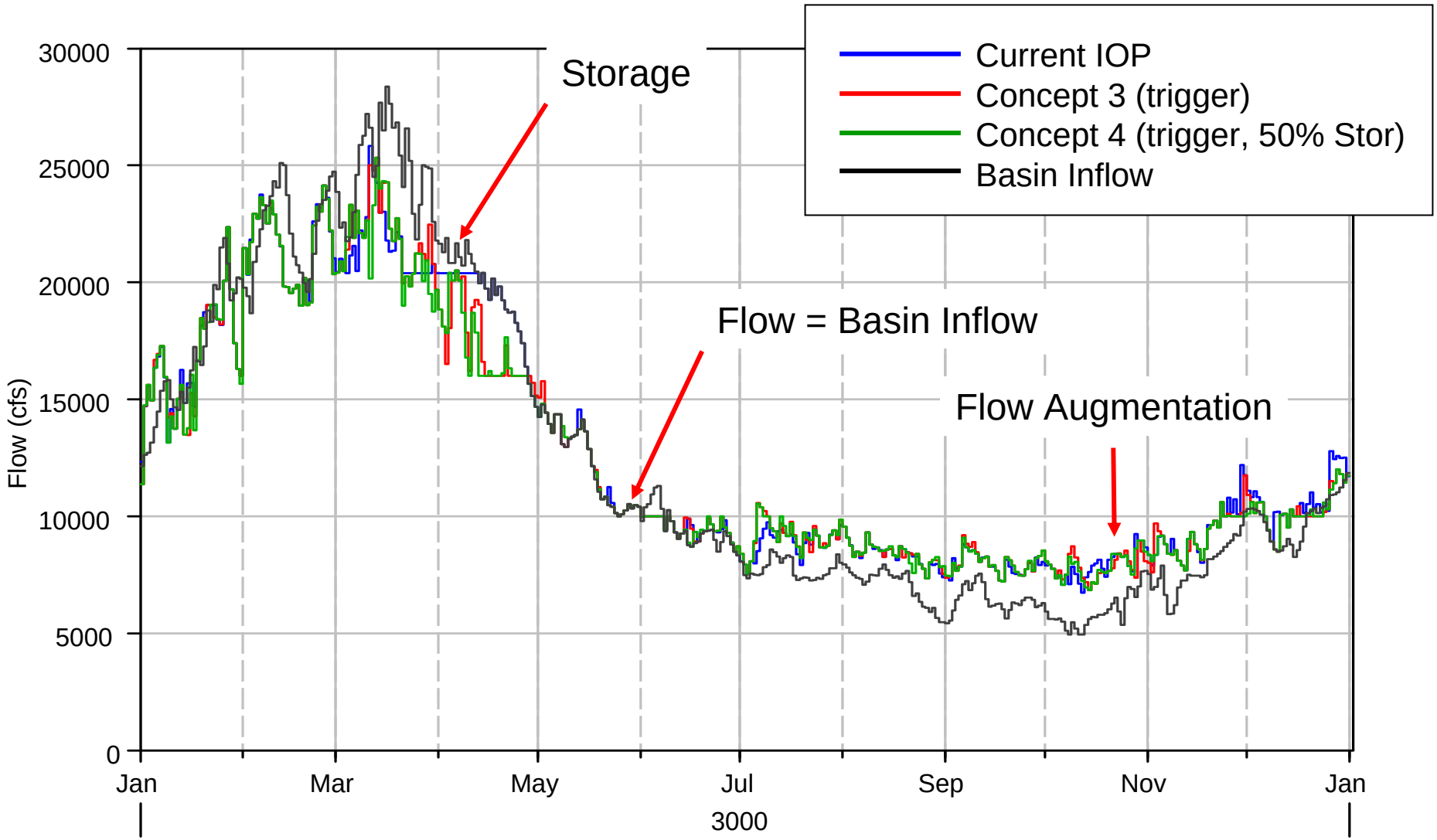
Chattahoochee Average Flow



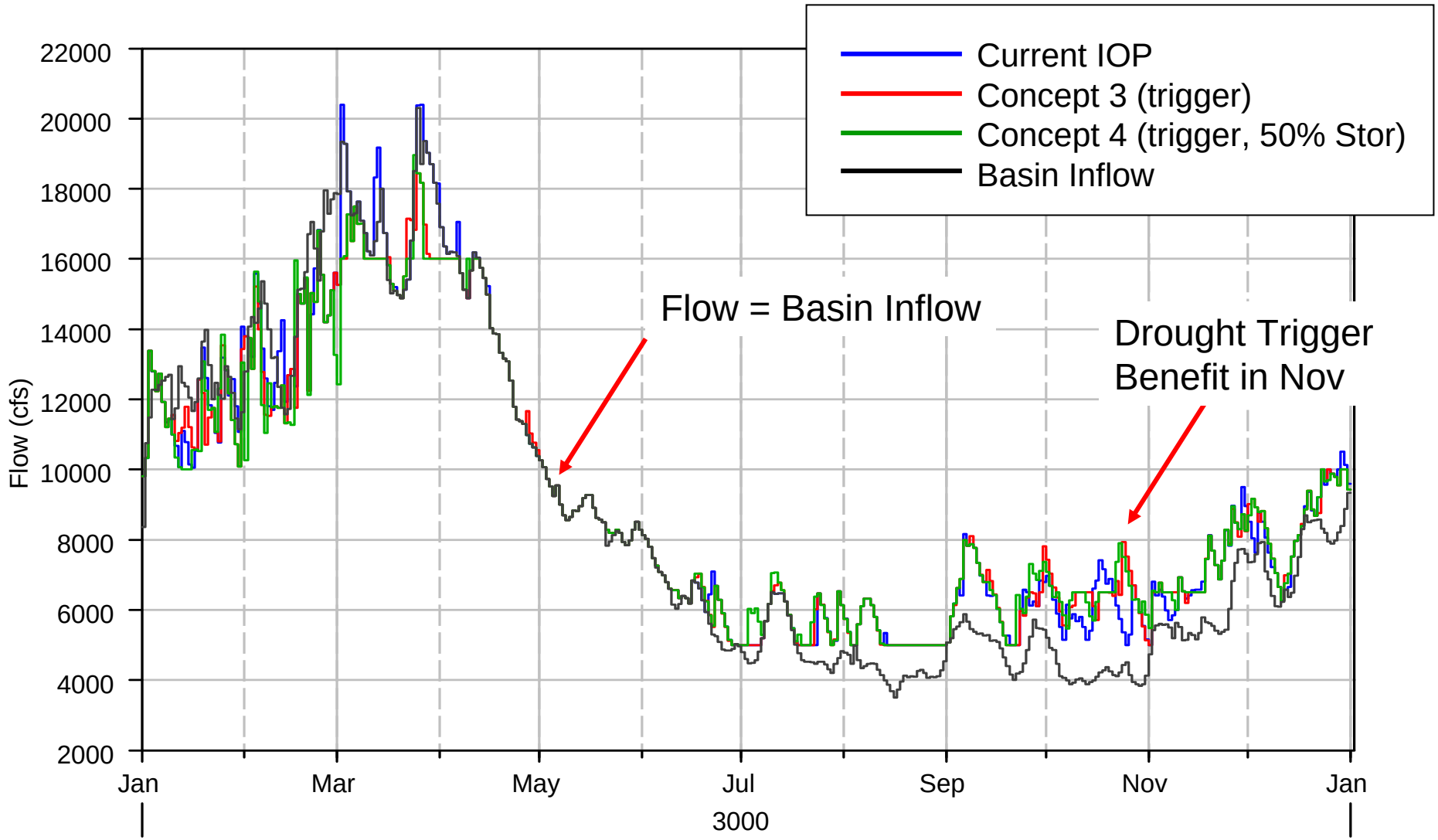
Chattahoochee 75 Percentile Flow



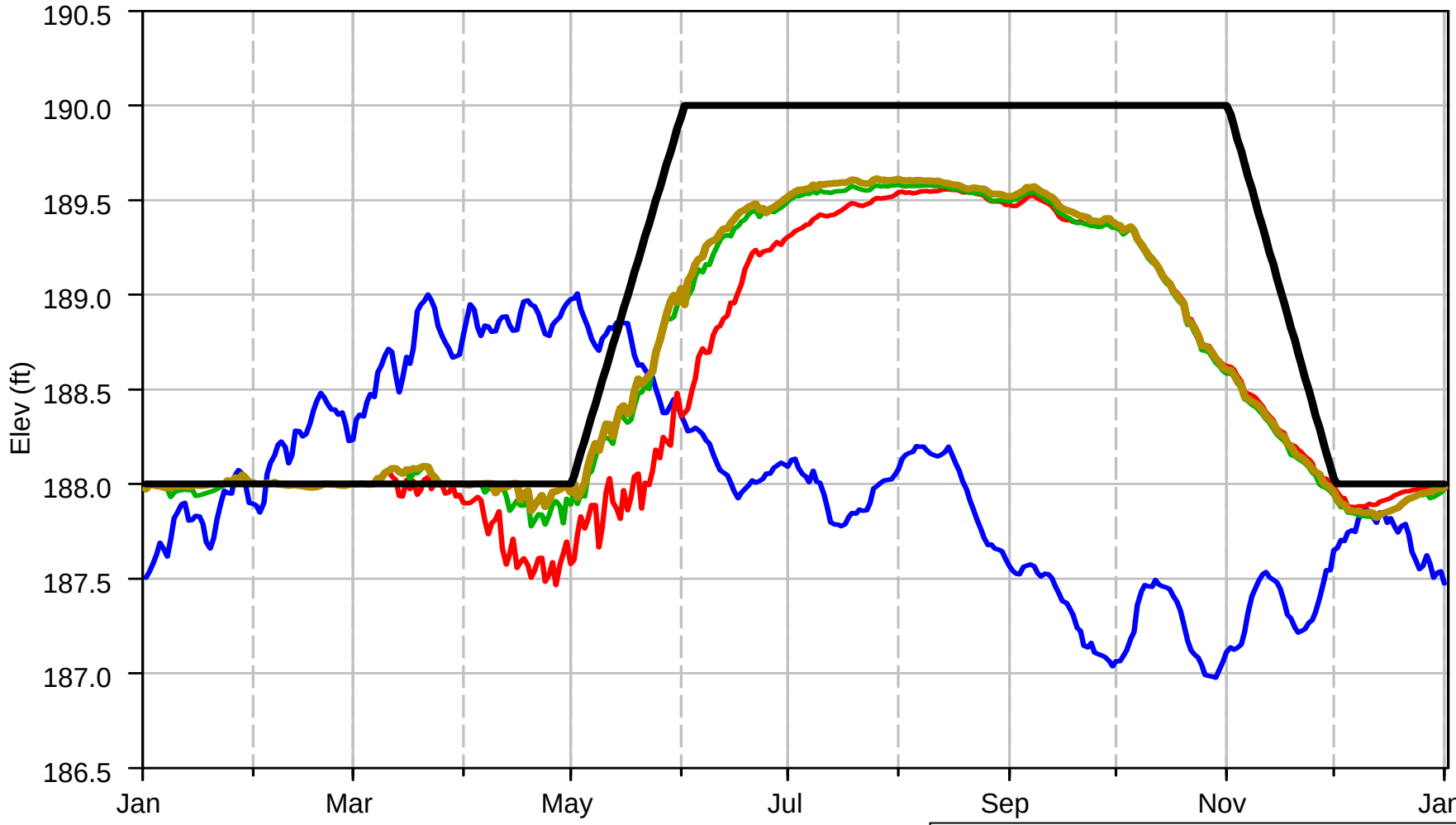
Chattahoochee 25 Percentile Flow



Chattahoochee 10 Percentile Flow



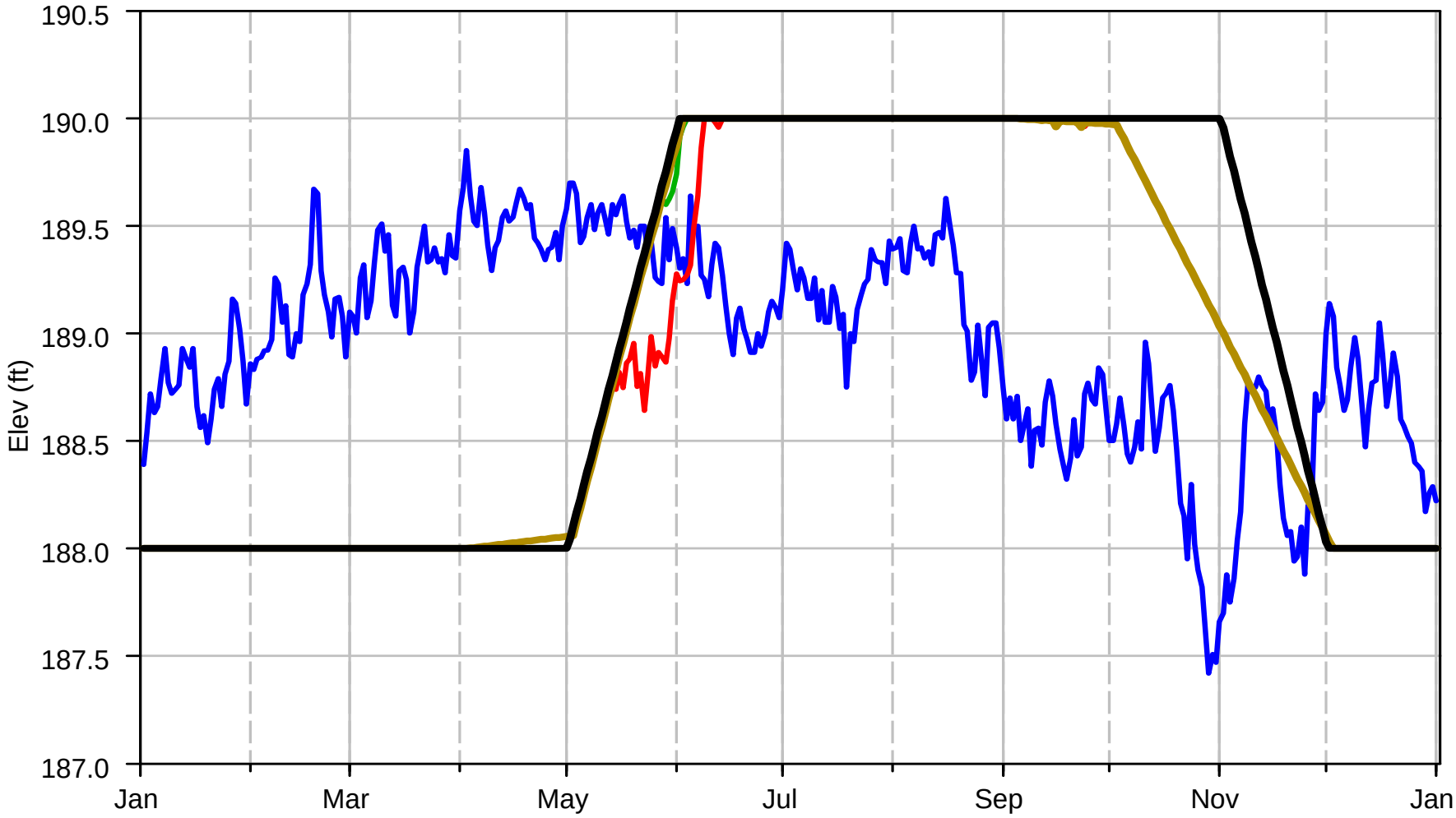
WF George Average Pool Elevation



W.F.GEORGE OBS_ADJ2[02JAN1976-01JAN2002] ELEV-AVER
W.F. GEORGE IOP23K_70I[02JAN1976-01JAN2002] ELEV-AVER
W.F. GEORGE IOP_6500-10K3[02JAN1976-01JAN2002] ELEV-AVER
W.F. GEORGE IOP_6500-50P3[02JAN1976-01JAN2002] ELEV-AVER
GEORGE RULE CURVE ELEV

Observed
Current IOP
Concept 3 (trigger)
Concept 4 (trigger, 50% Stor)

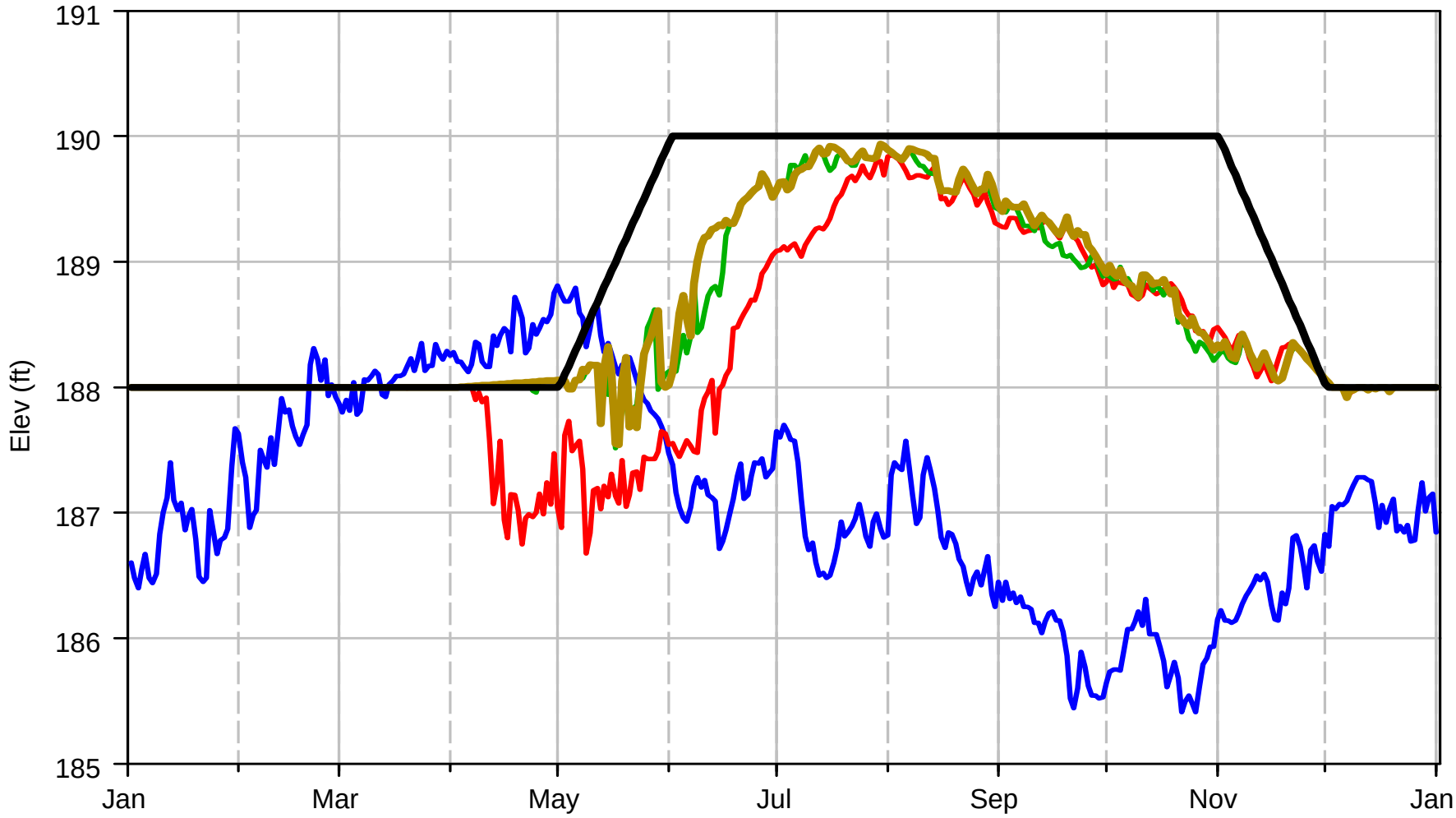
WF George 75 Percentile Pool Elevation



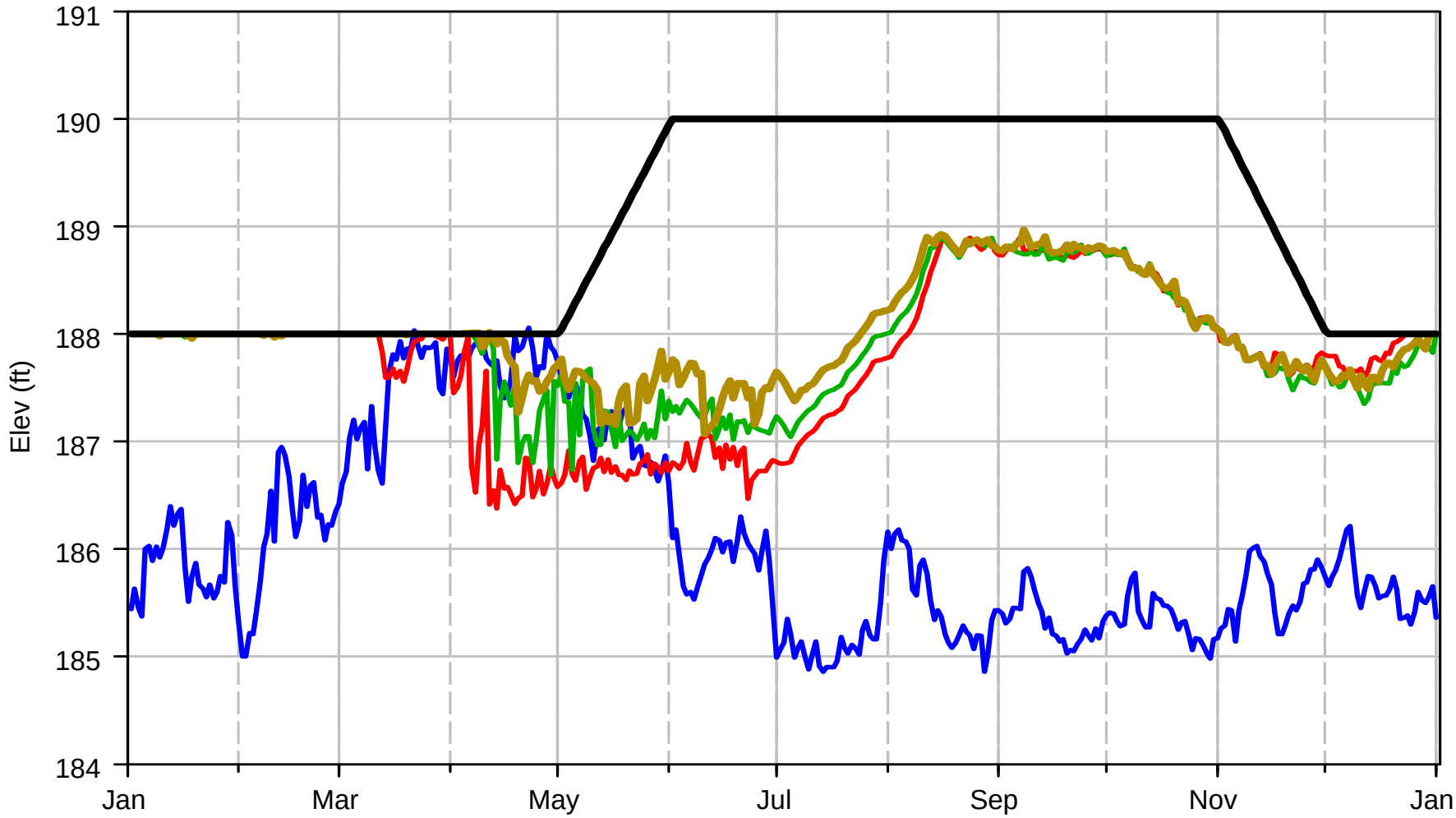
W.F.GEORGE OBS_ADJ2[02JAN1976-01JAN2002] ELEV-P75
W.F. GEORGE IOP23K_70I[02JAN1976-01JAN2002] ELEV-P75
W.F. GEORGE IOP_6500-10K3[02JAN1976-01JAN2002] ELEV-P75
W.F. GEORGE IOP_6500-50P3[02JAN1976-01JAN2002] ELEV-P75
GEORGE RULE CURVE ELEV

Observed
Current IOP
Concept 3 (trigger)
Concept 4 (trigger, 50% Stor)

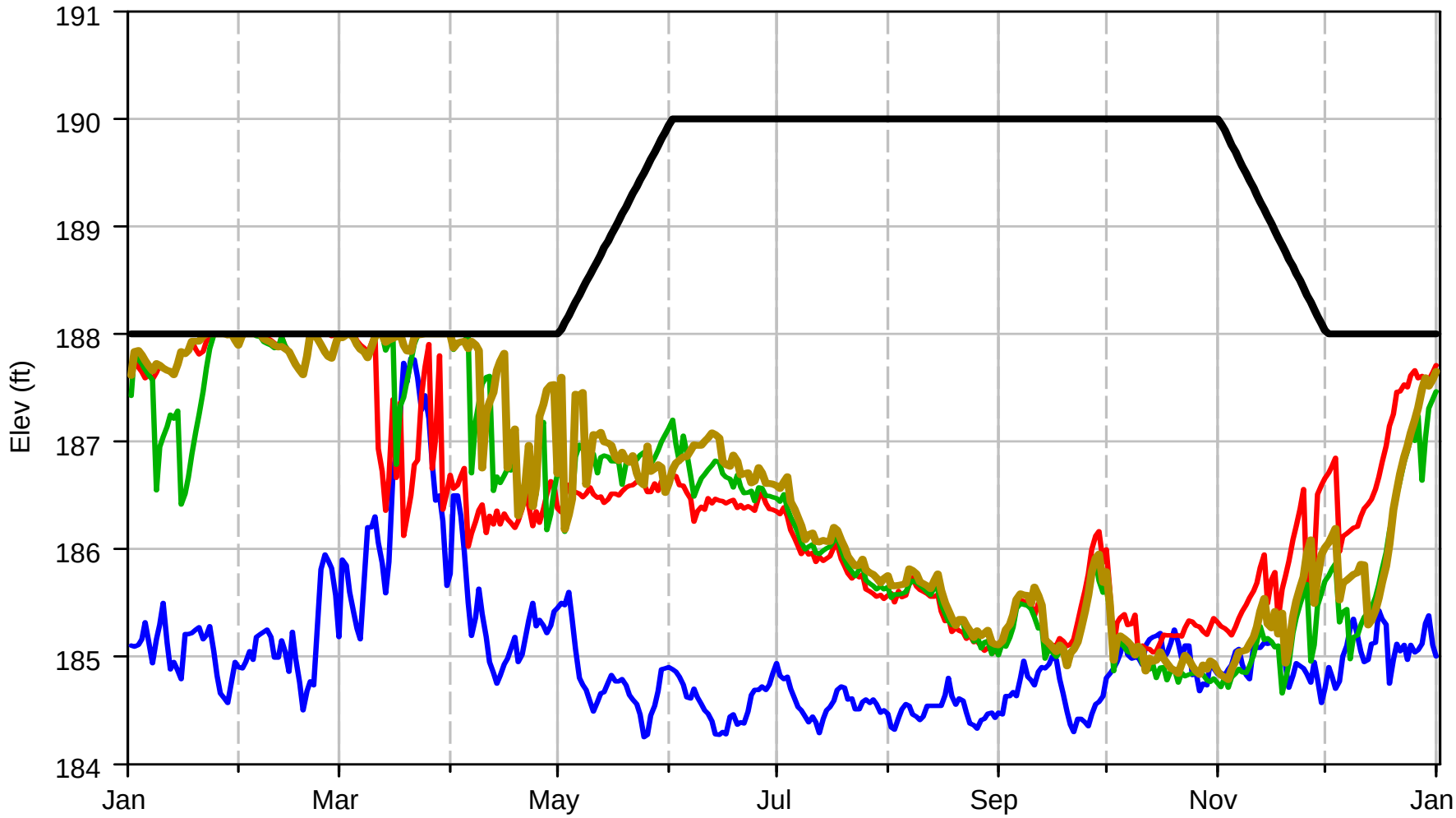
WF George 25 Percentile Pool Elevation



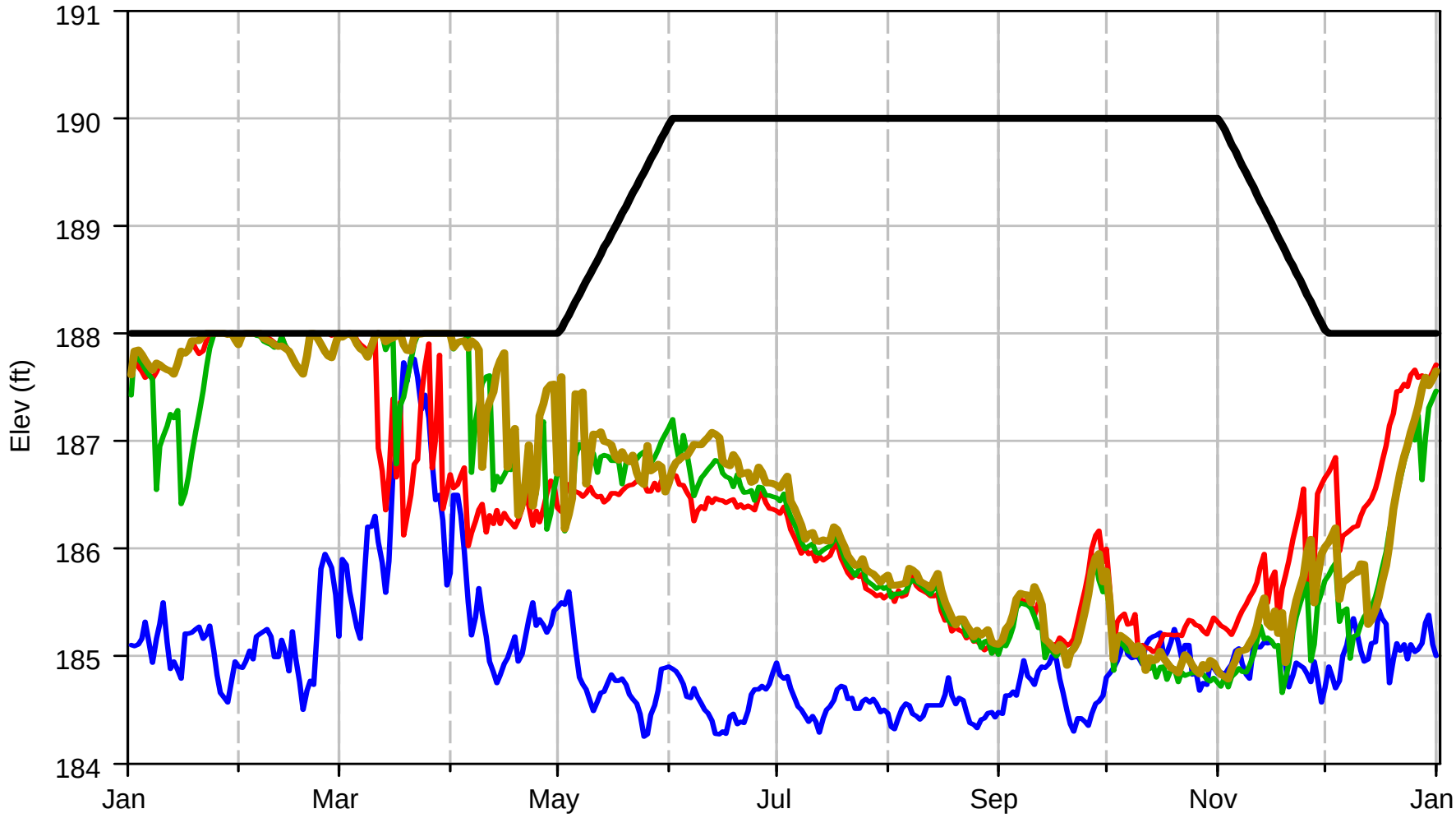
WF George 10 Percentile Pool Elevation



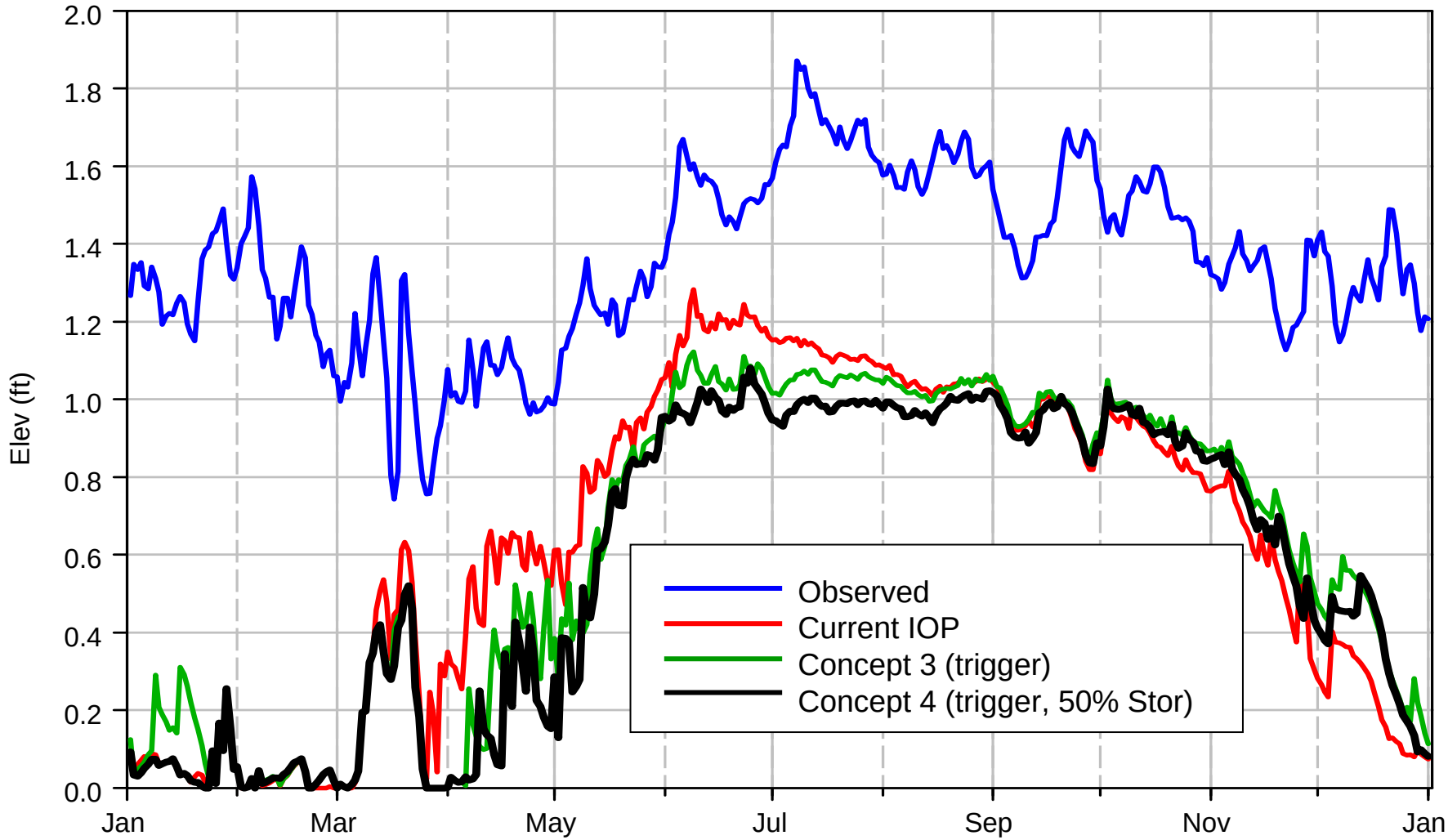
WF George 5 Percentile Pool Elevation



WF George Minimum Pool Elevation

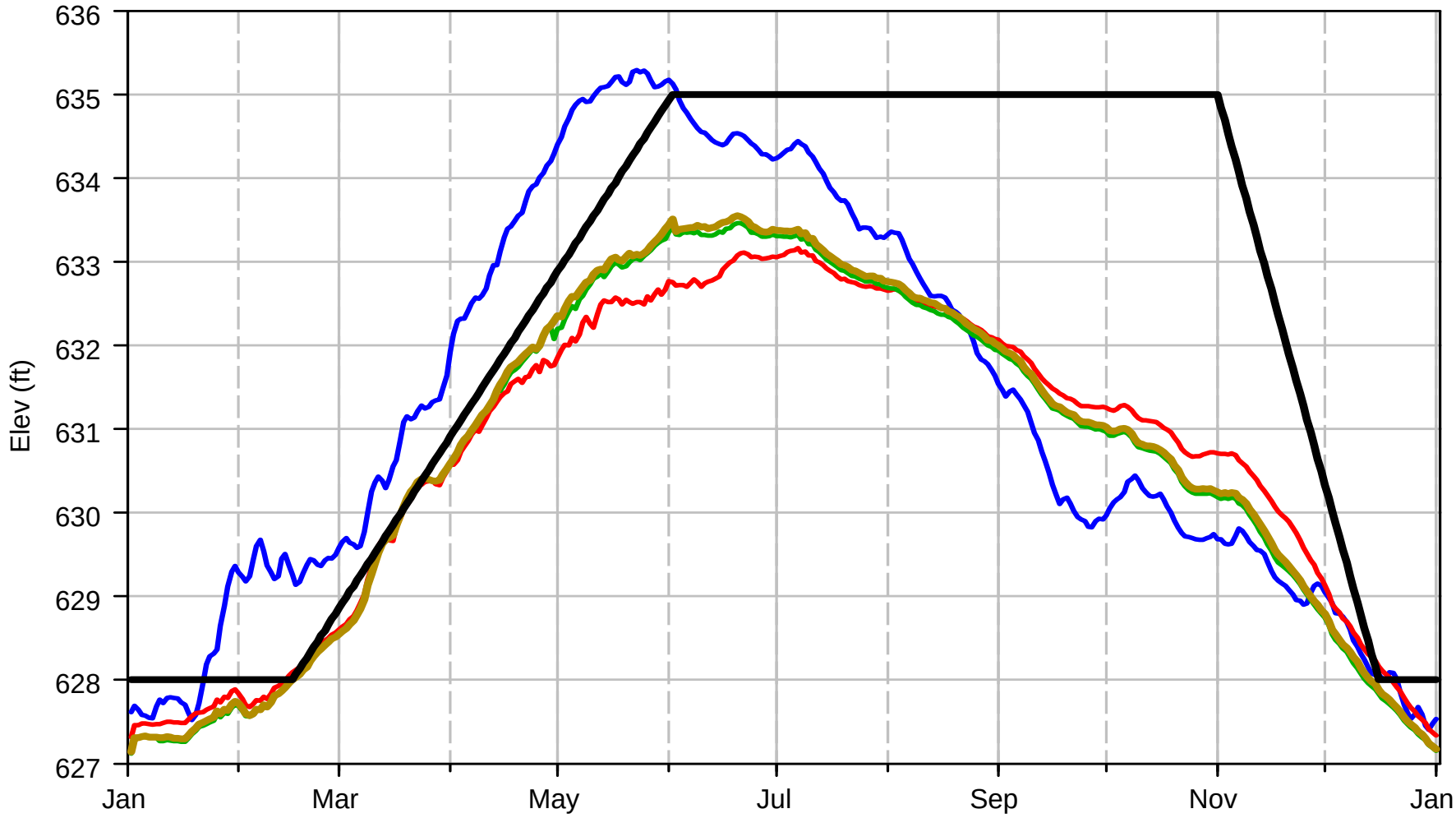


WF George Pool Elevation Standard Deviation

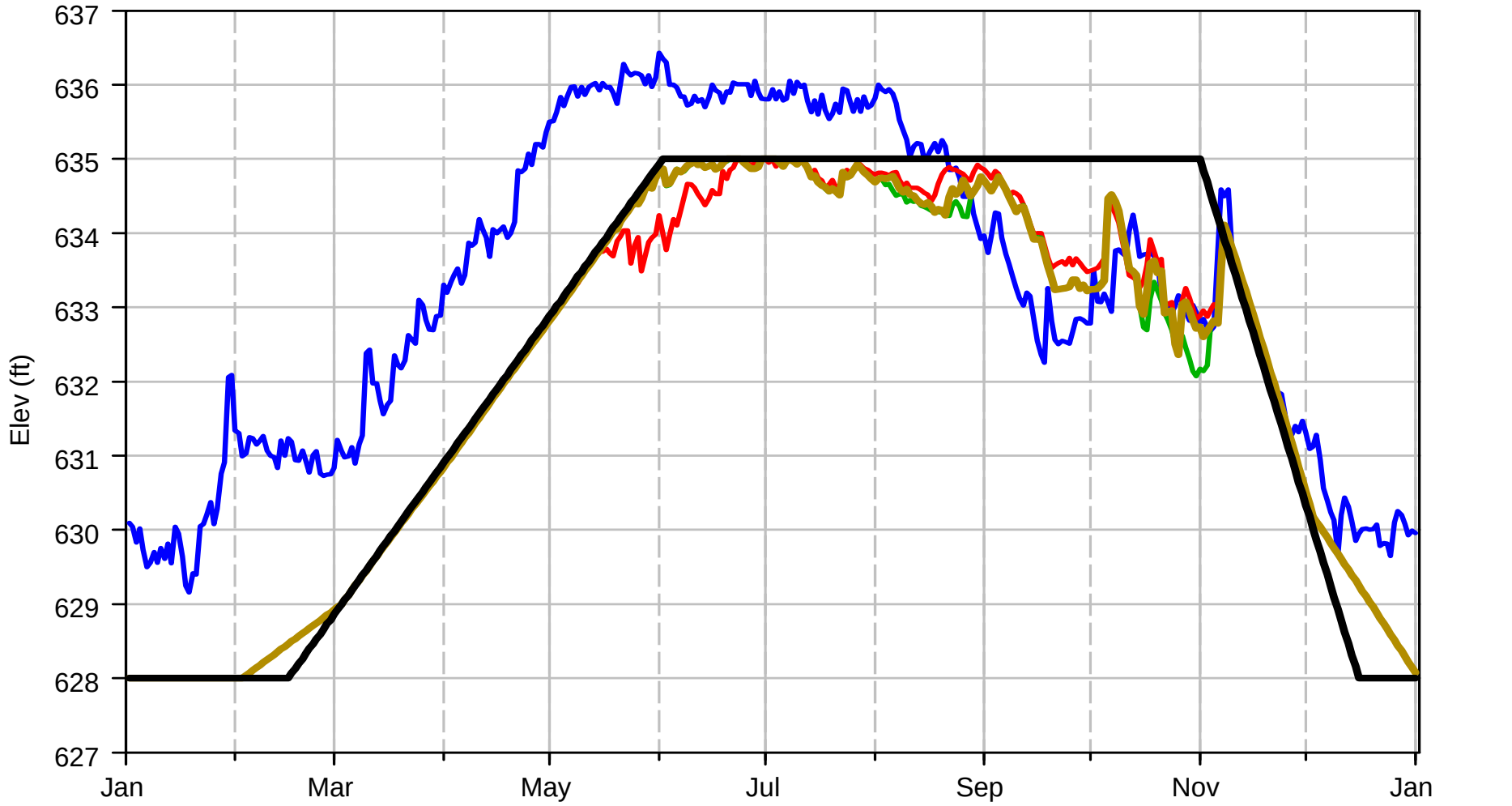


W.F.GEORGE OBS_ADJ2[02JAN1976-01JAN2002] ELEV-SD
W.F. GEORGE IOP23K_70I[02JAN1976-01JAN2002] ELEV-SD
W.F. GEORGE IOP_6500-10K3[02JAN1976-01JAN2002] ELEV-SD
W.F. GEORGE IOP_6500-50P3[02JAN1976-01JAN2002] ELEV-SD

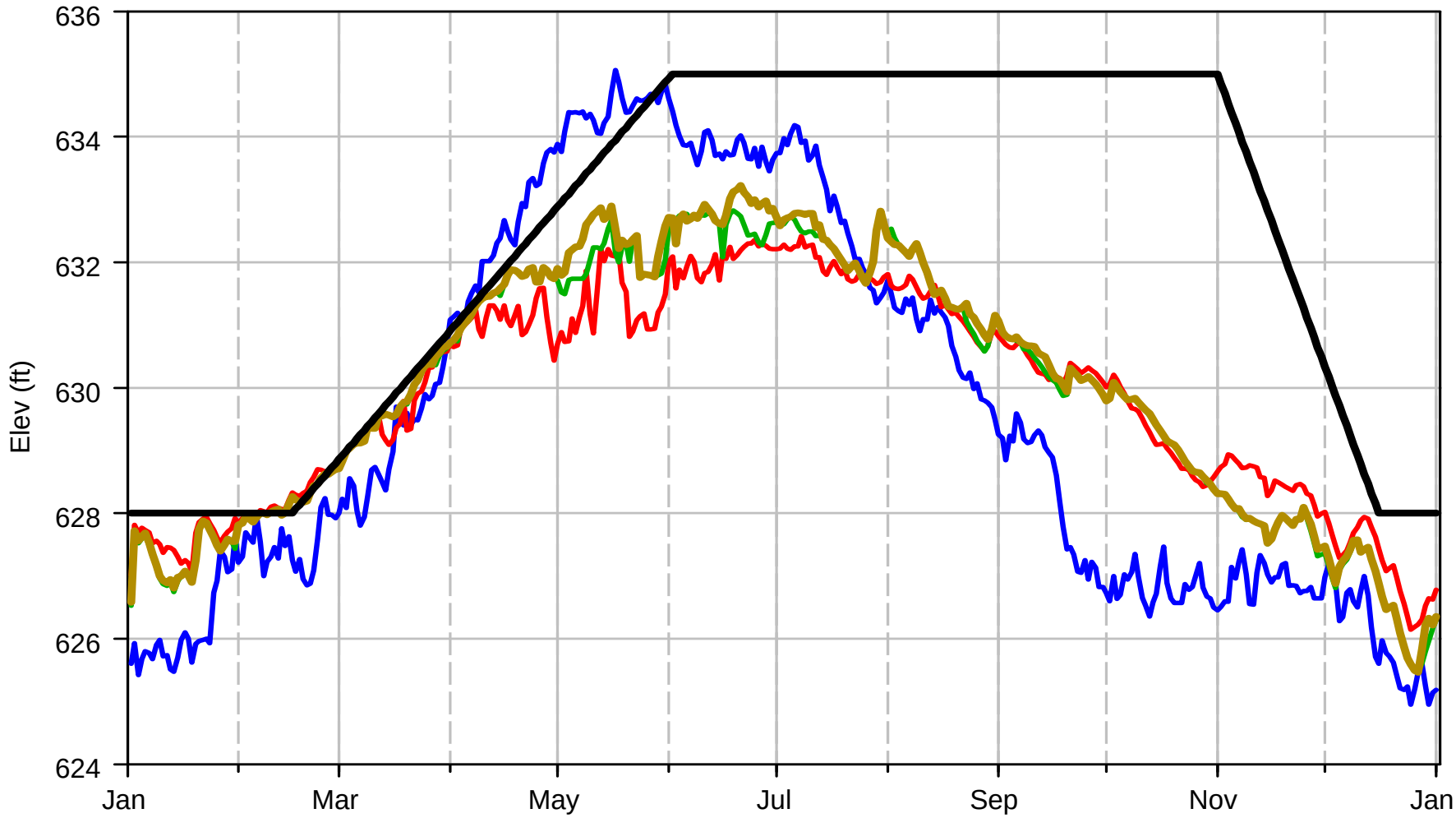
West Point Average Pool Elevation



West Point 75 Percentile Pool Elevation



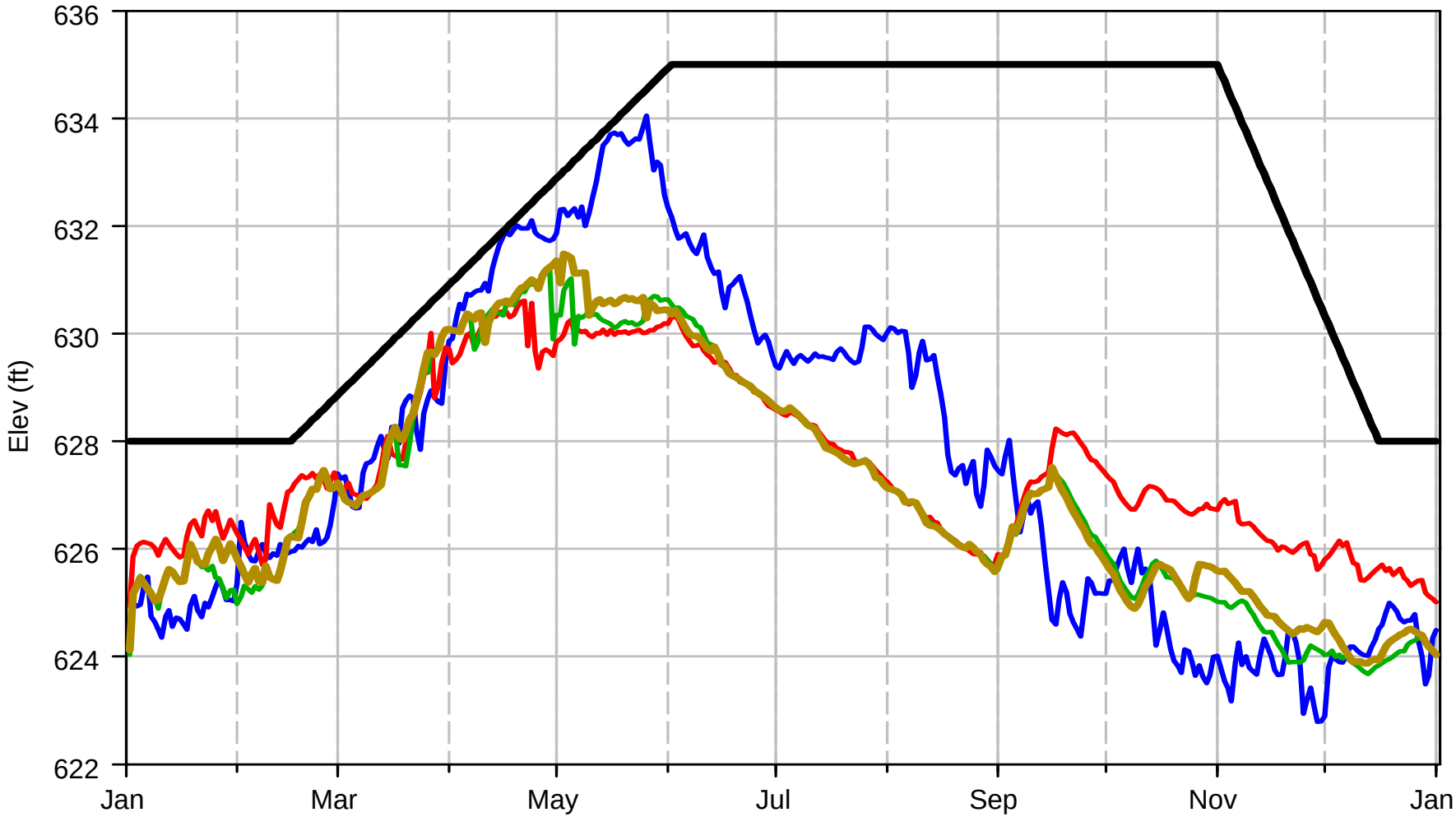
West Point 25 Percentile Pool Elevation



WEST POINT R OBS_ADJ2[02JAN1976-01JAN2002] ELEV-P25
WEST POINT IOP23K_70I[02JAN1976-01JAN2002] ELEV-P25
WEST POINT IOP_6500-10K3[02JAN1976-01JAN2002] ELEV-P25
WEST POINT IOP_6500-50P3[02JAN1976-01JAN2002] ELEV-P25
WEST POINT RULE CURVE ELEV

Observed
Current IOP
Concept 3 (trigger)
Concept 4 (trigger, 50% Stor)

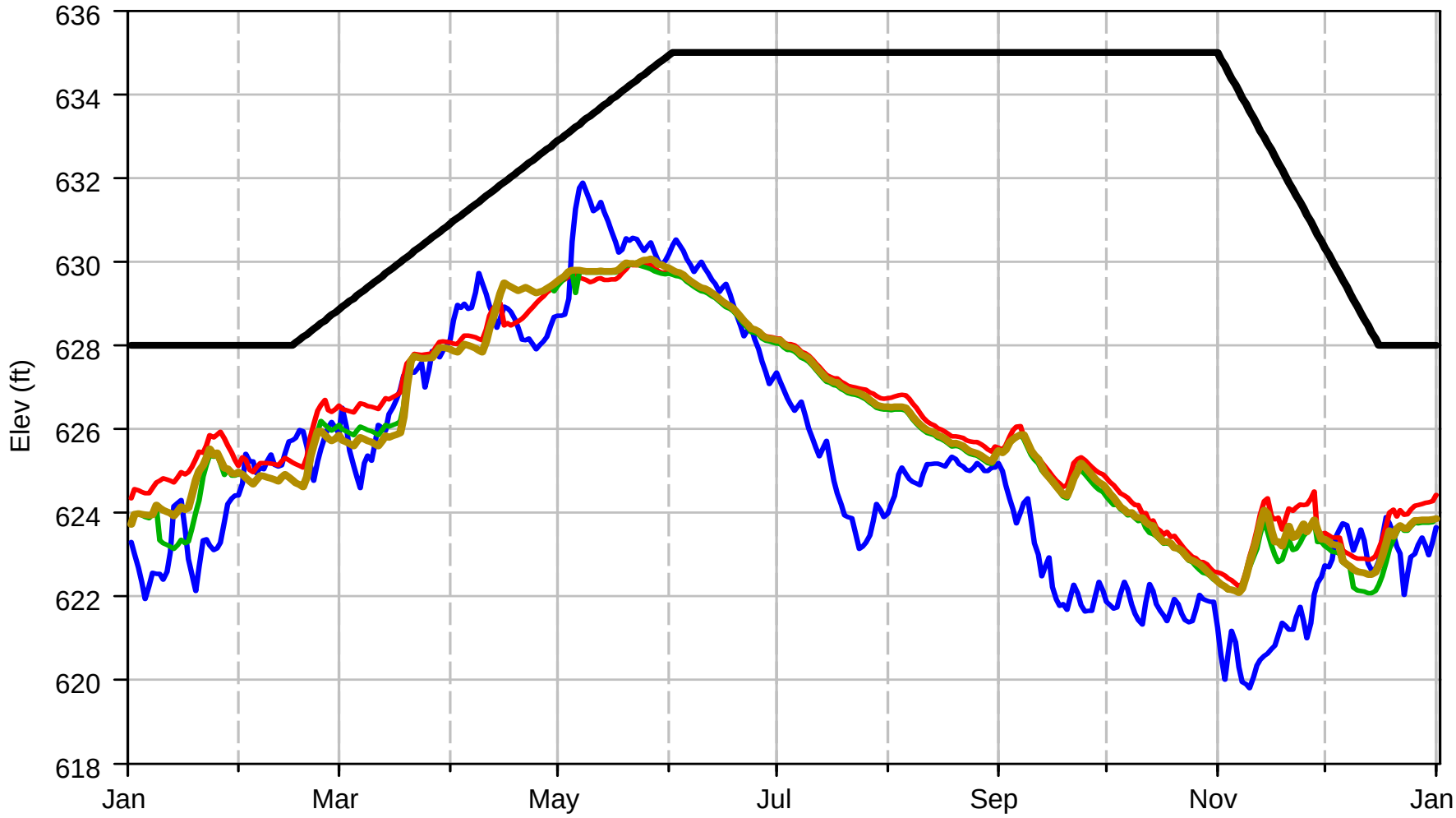
West Point 10 Percentile Pool Elevation



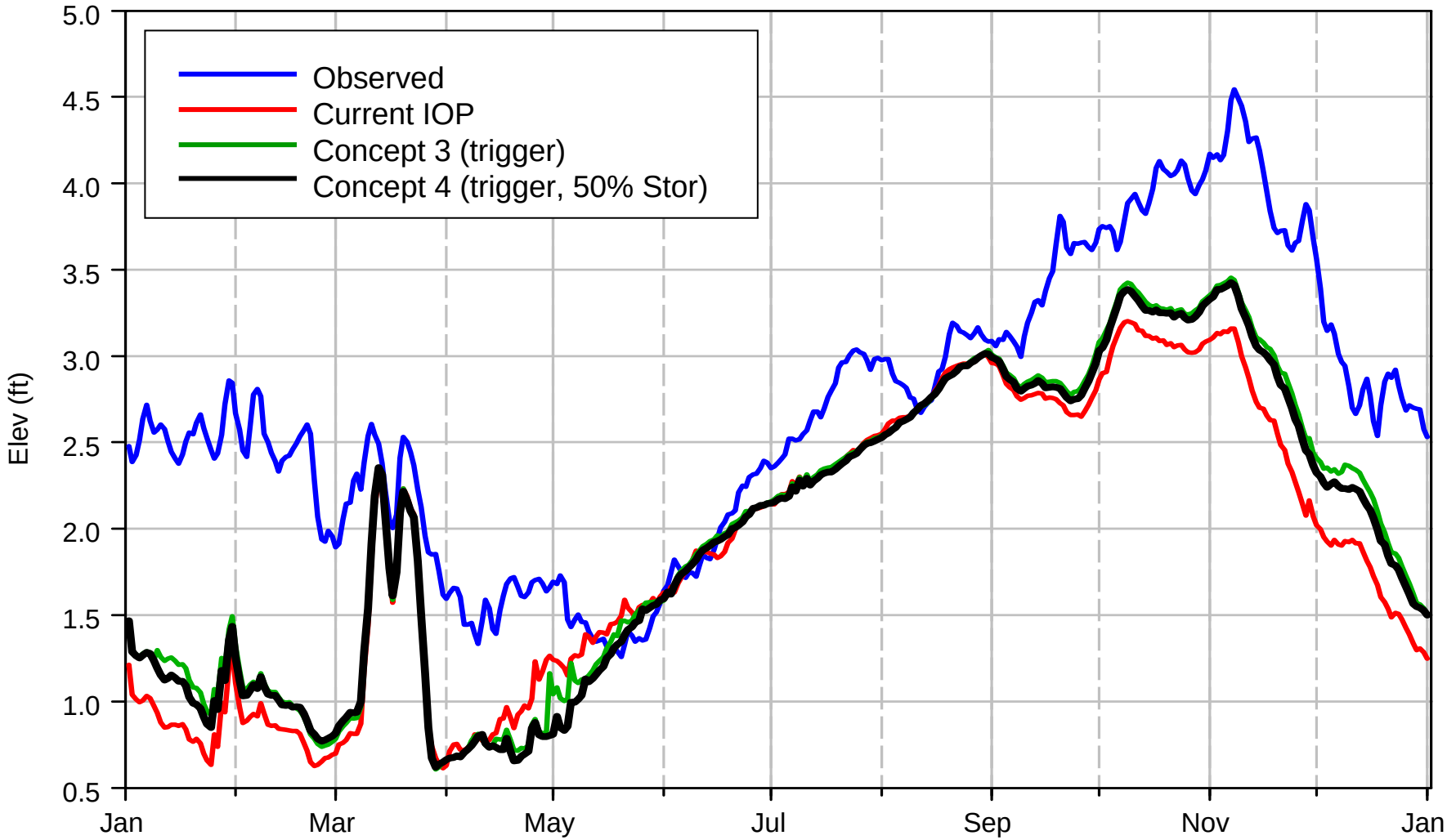
WEST POINT R OBS_ADJ2[02JAN1976-01JAN2002] ELEV-P10
WEST POINT IOP23K_70I[02JAN1976-01JAN2002] ELEV-P10
WEST POINT IOP_6500-10K3[02JAN1976-01JAN2002] ELEV-P10
WEST POINT IOP_6500-50P3[02JAN1976-01JAN2002] ELEV-P10
WEST POINT RULE CURVE ELEV

Observed
Current IOP
Concept 3 (trigger)
Concept 4 (trigger, 50% Stor)

West Point Minimum Pool Elevation

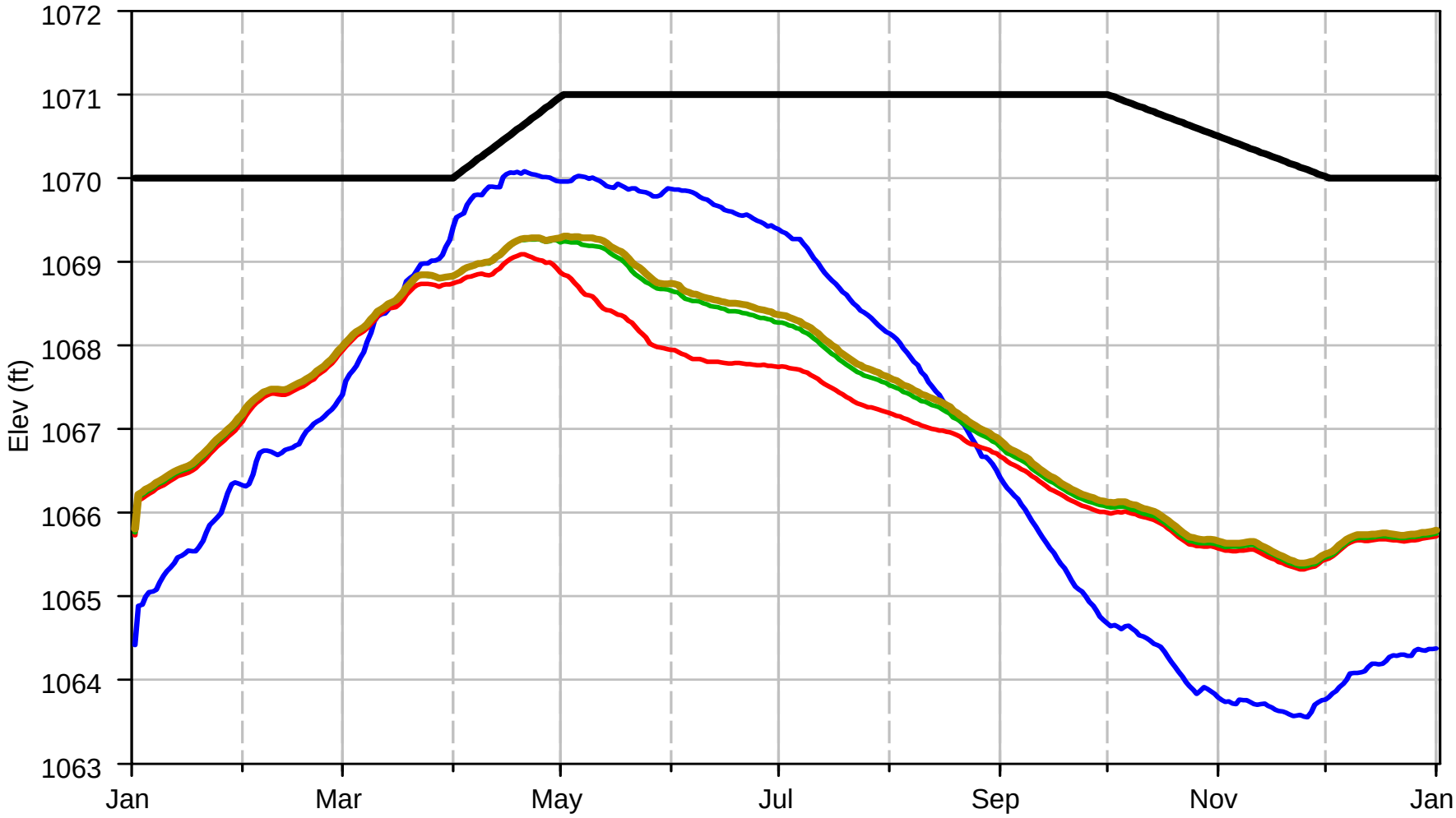


West Point Pool Elevation Standard Deviation

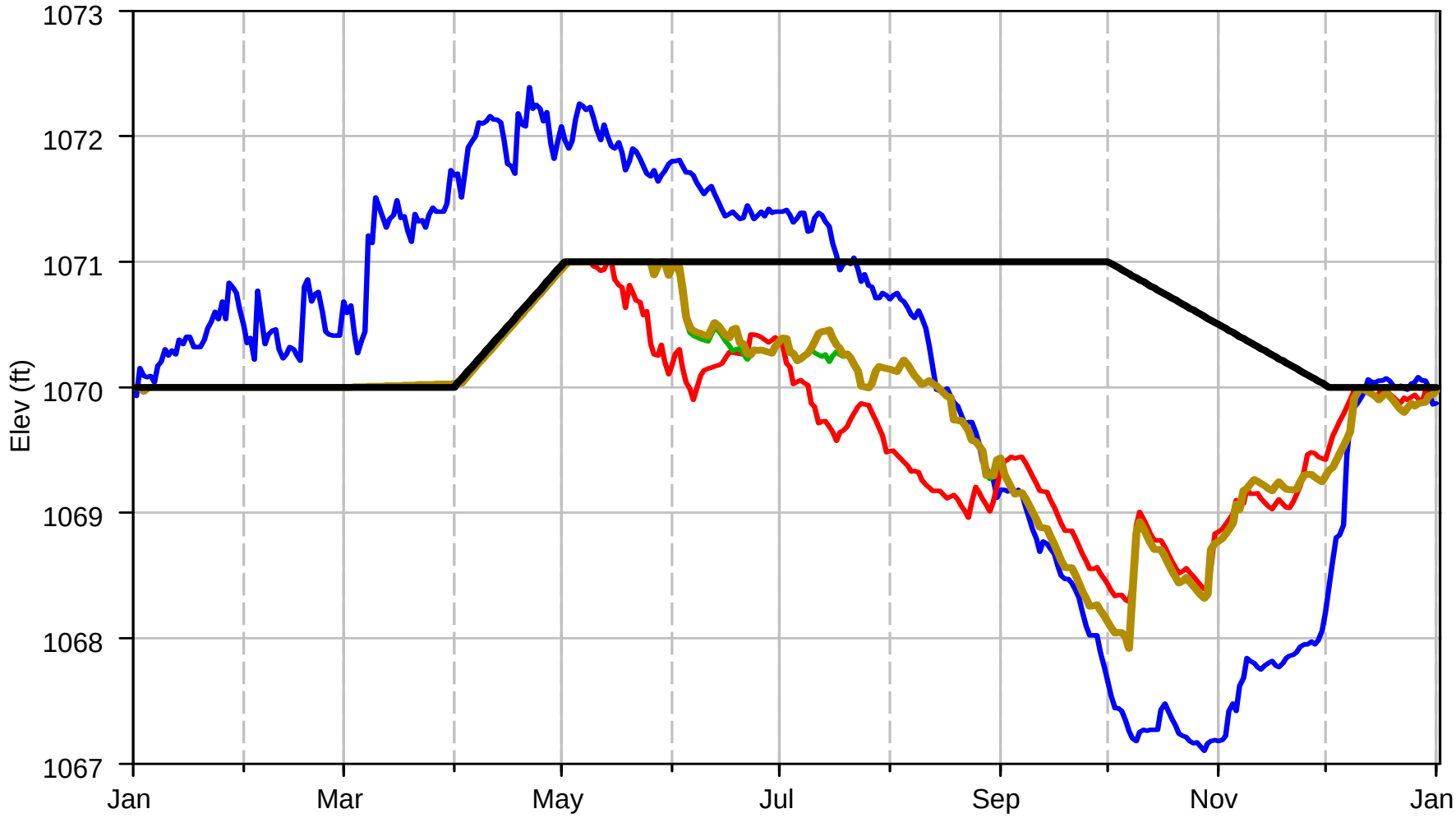


WEST POINT R OBS_ADJ2[02JAN1976-01JAN2002] ELEV-SD
WEST POINT IOP23K_70I[02JAN1976-01JAN2002] ELEV-SD
WEST POINT IOP_6500-10K3[02JAN1976-01JAN2002] ELEV-SD
WEST POINT IOP_6500-50P3[02JAN1976-01JAN2002] ELEV-SD

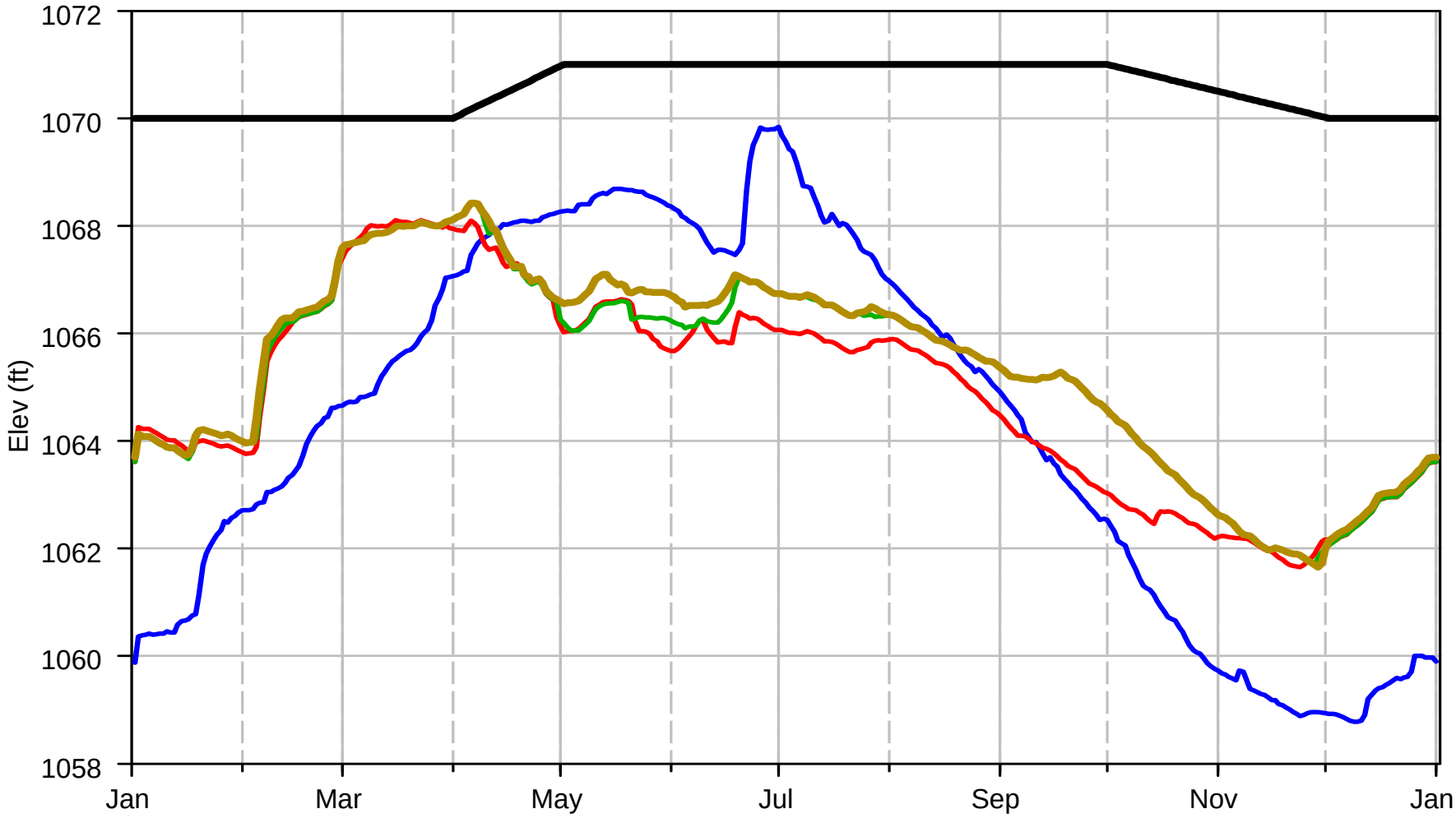
Buford Average Pool Elevation



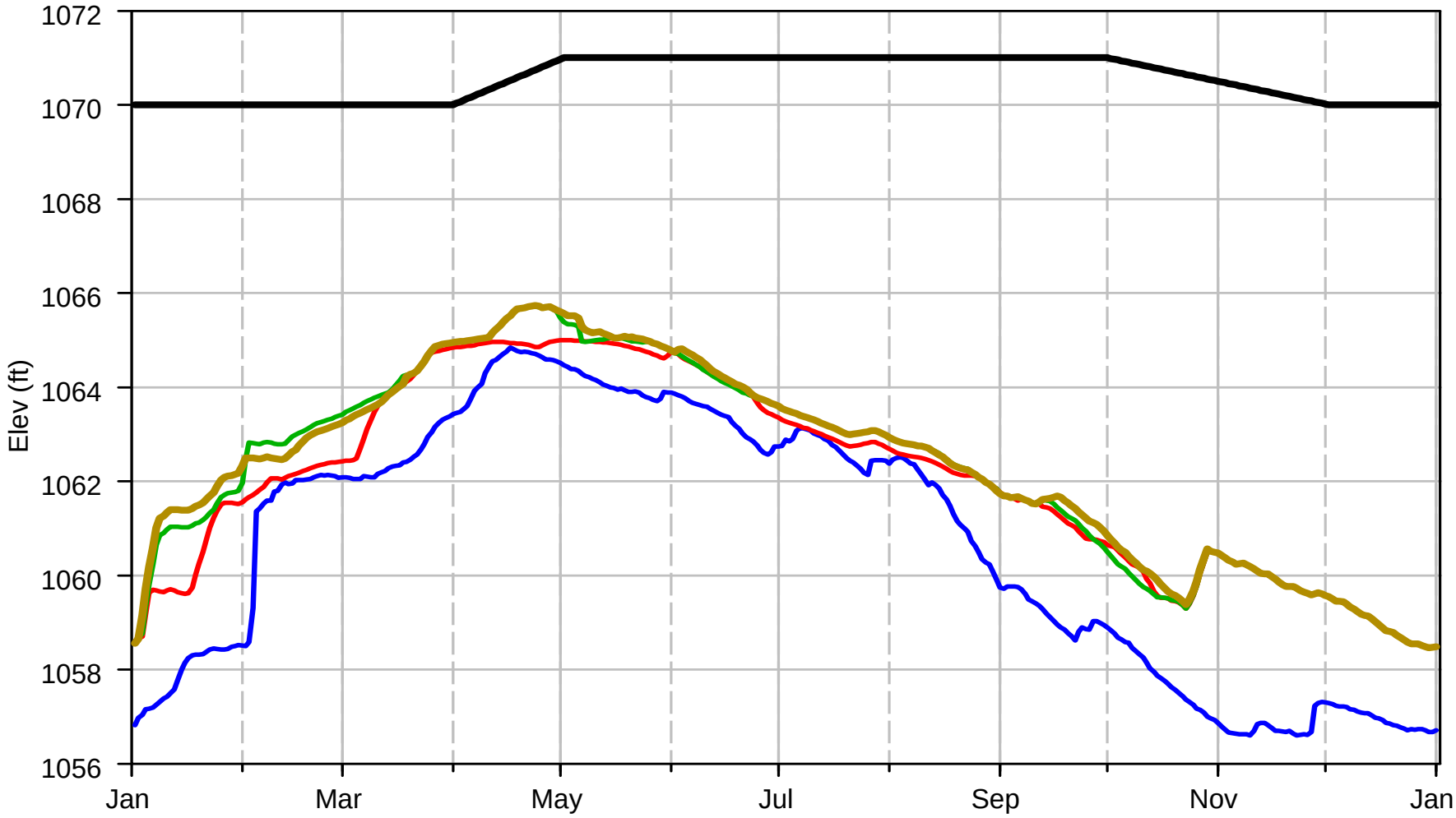
Buford 75 Percentile Pool Elevation



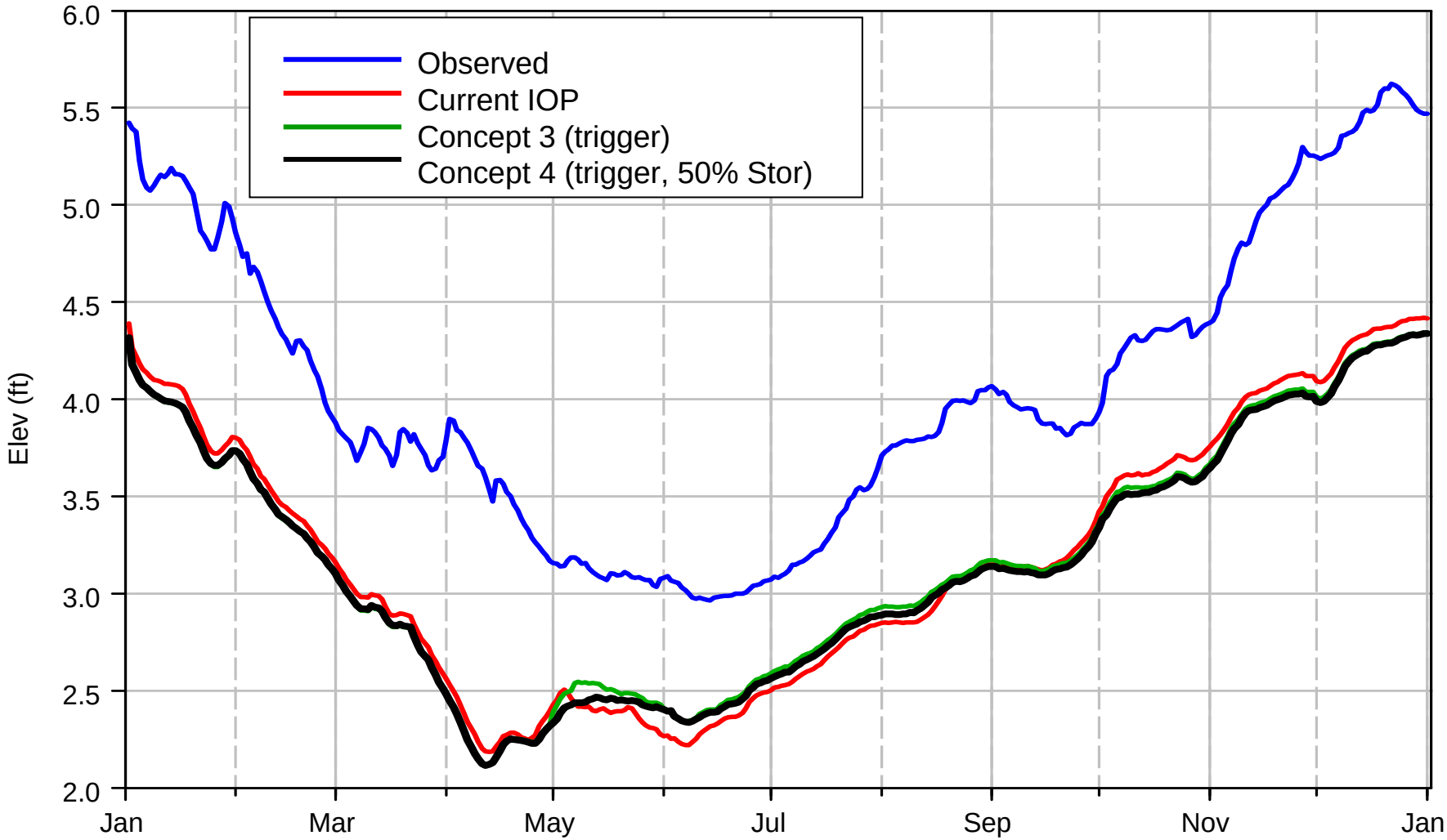
Buford 25 Percentile Pool Elevation



Buford 10 Percentile Pool Elevation



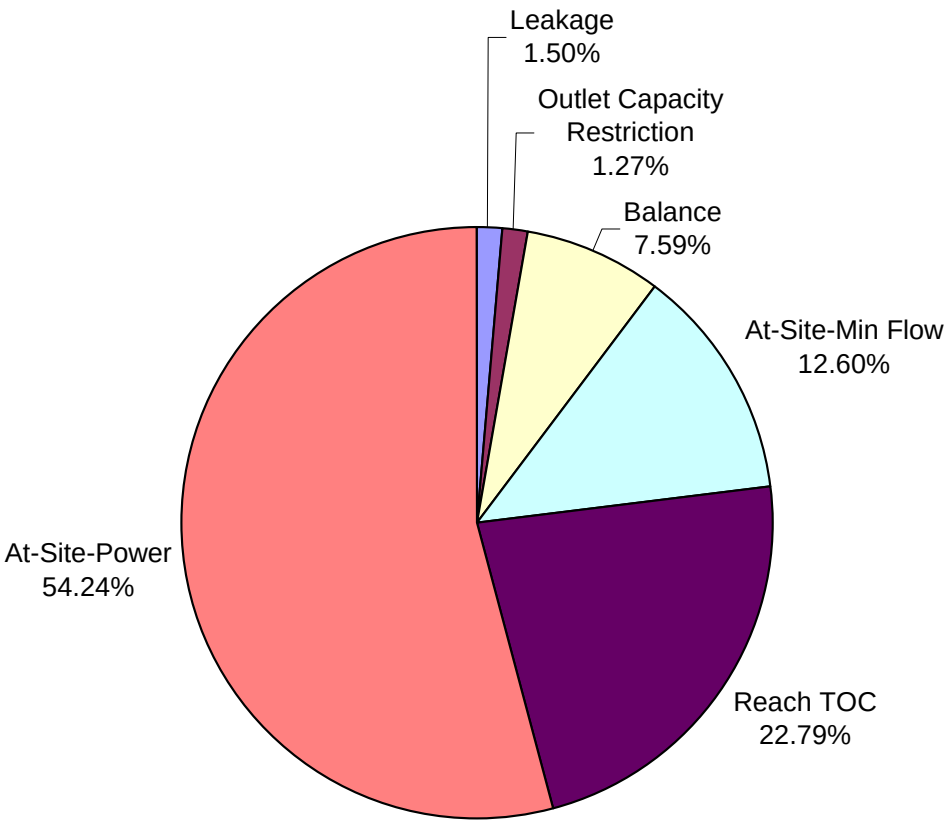
Buford Pool Elevation Standard Deviation



BUFORD OBS_ADJ[02JAN1976-01JAN2002] ELEV-SD
BUFORD DAM IOP23K_70I[02JAN1976-01JAN2002] ELEV-SD
BUFORD DAM IOP_6500-10K3[02JAN1976-01JAN2002] ELEV-SD
BUFORD DAM IOP_6500-50P3[02JAN1976-01JAN2002] ELEV-SD

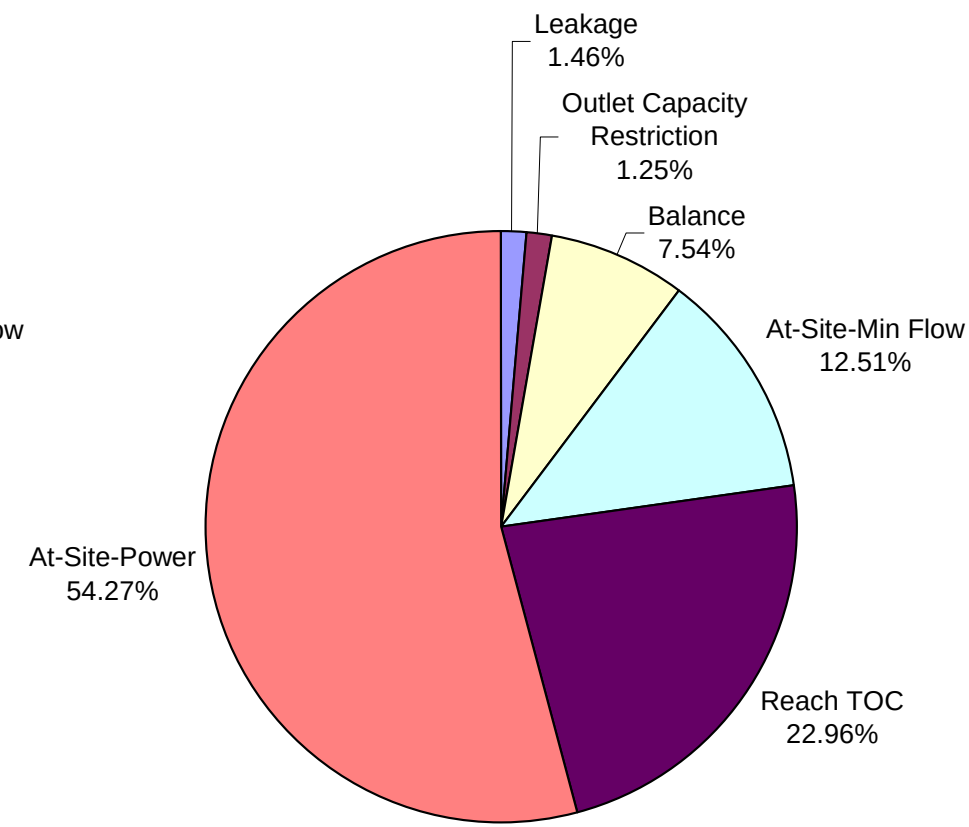
Concept 3

Buford Cases "Why Release Made" 1939-2001

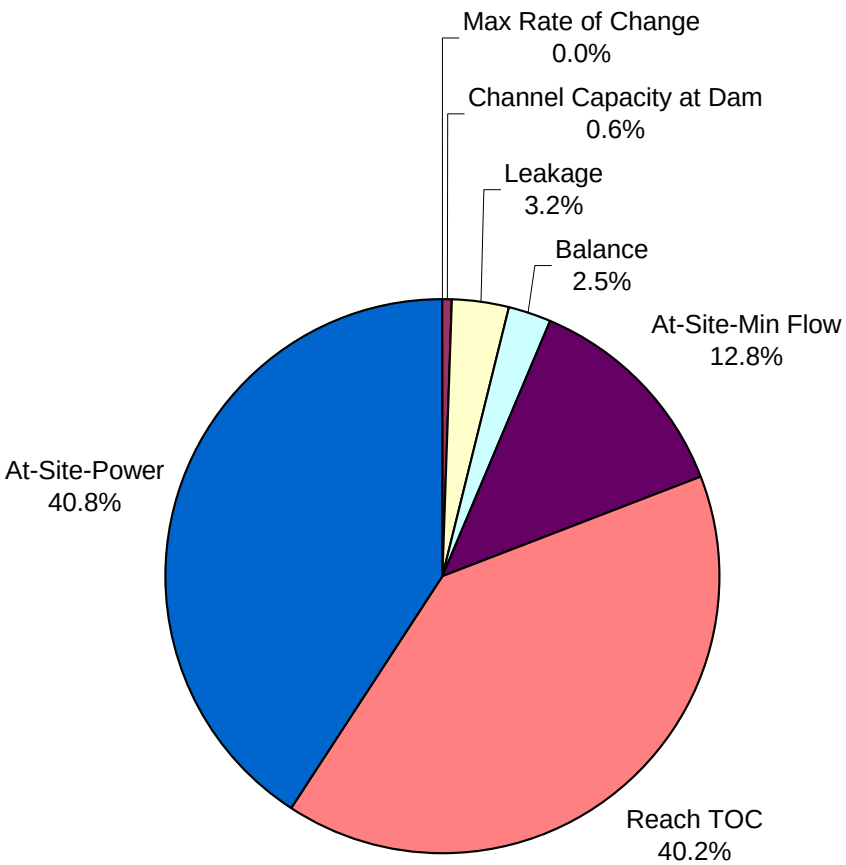


Concept 4

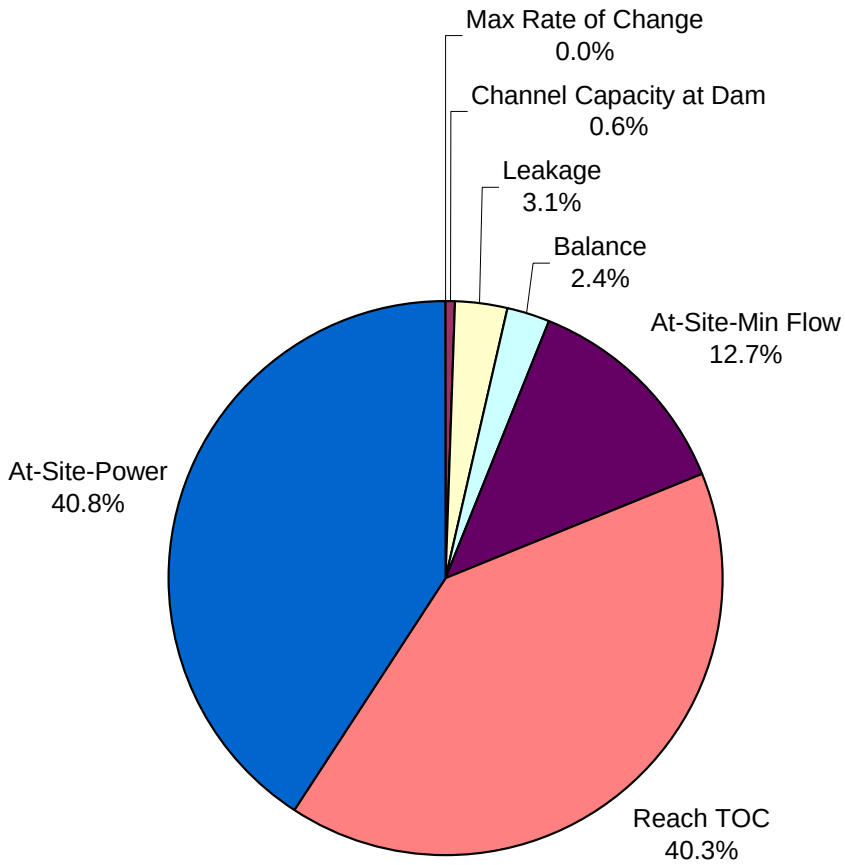
Buford Cases "Why Release Made" 1939-2001



Concept 3

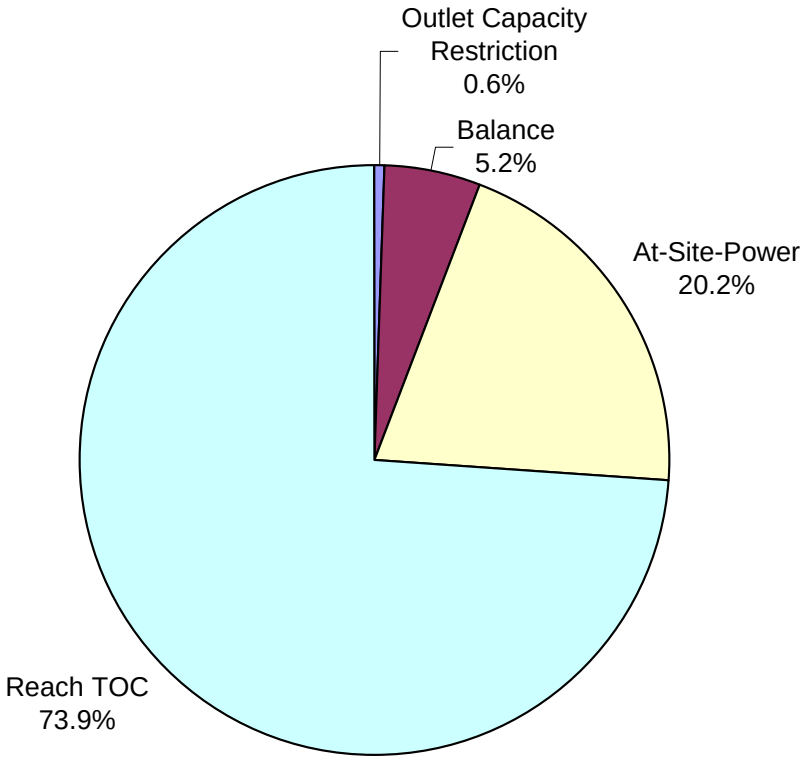


Concept 4



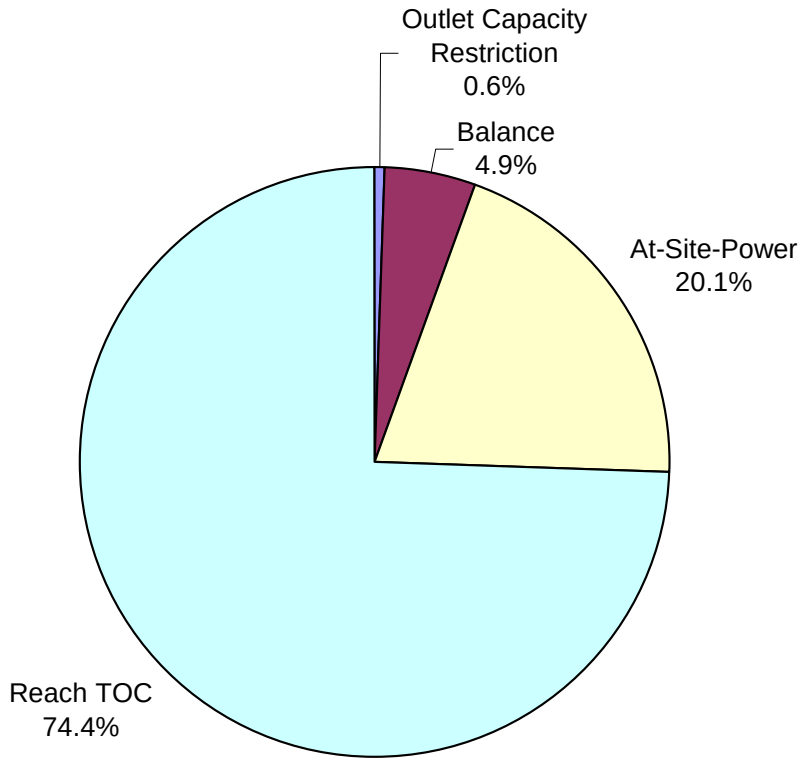
Concept 3

WF George Cases "Why Release Made" 1939-2001



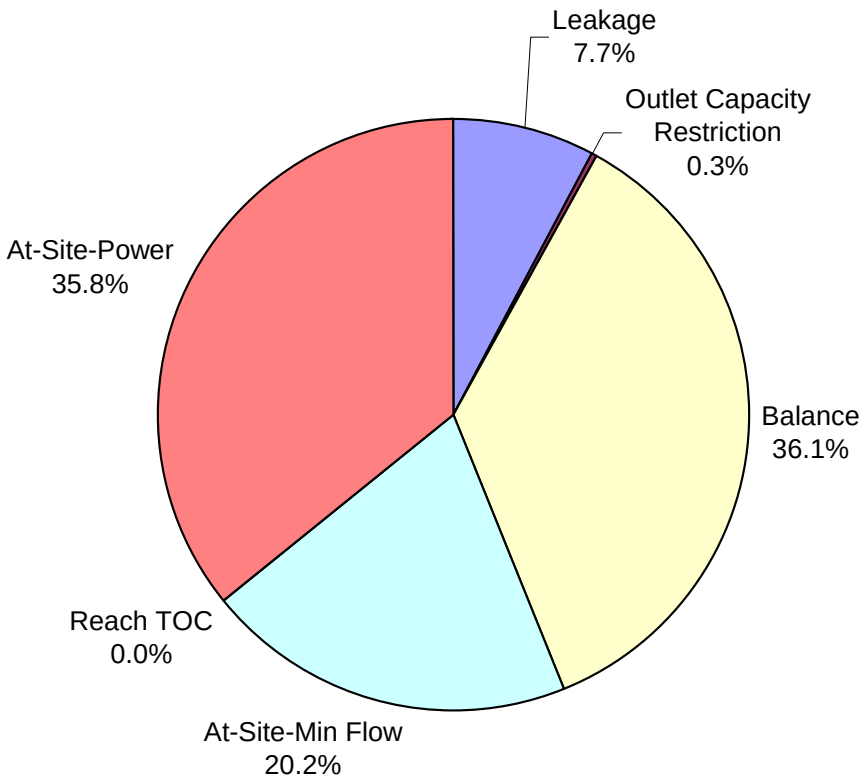
Concept 4

WF George Cases "Why Release Made" 1939-2001



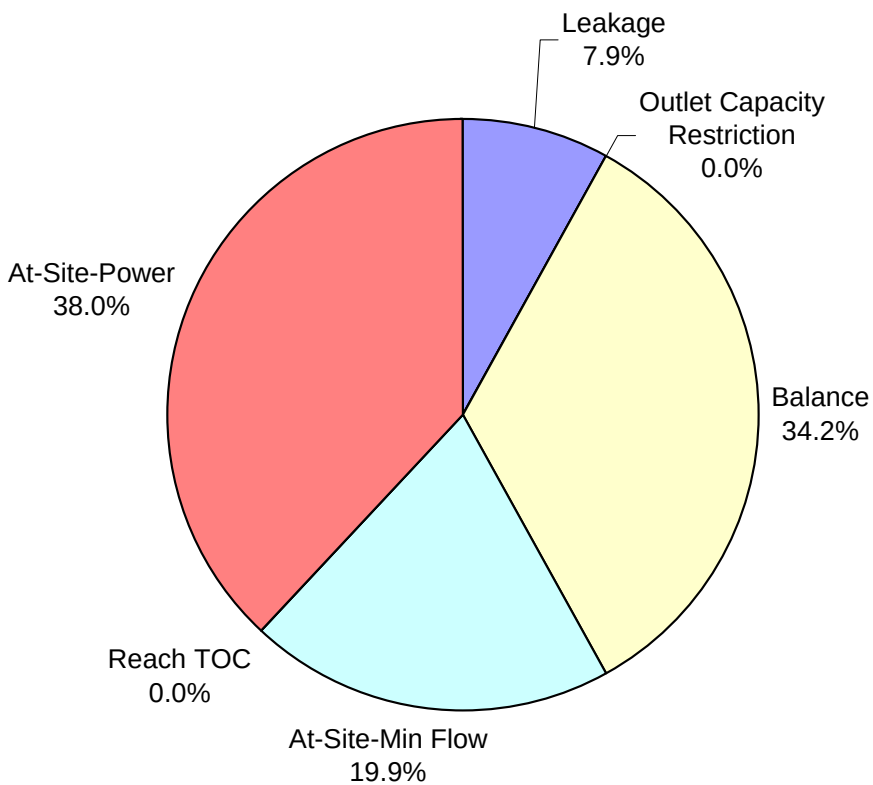
Concept 3

Buford Cases "Why Release Made"
Year 2000



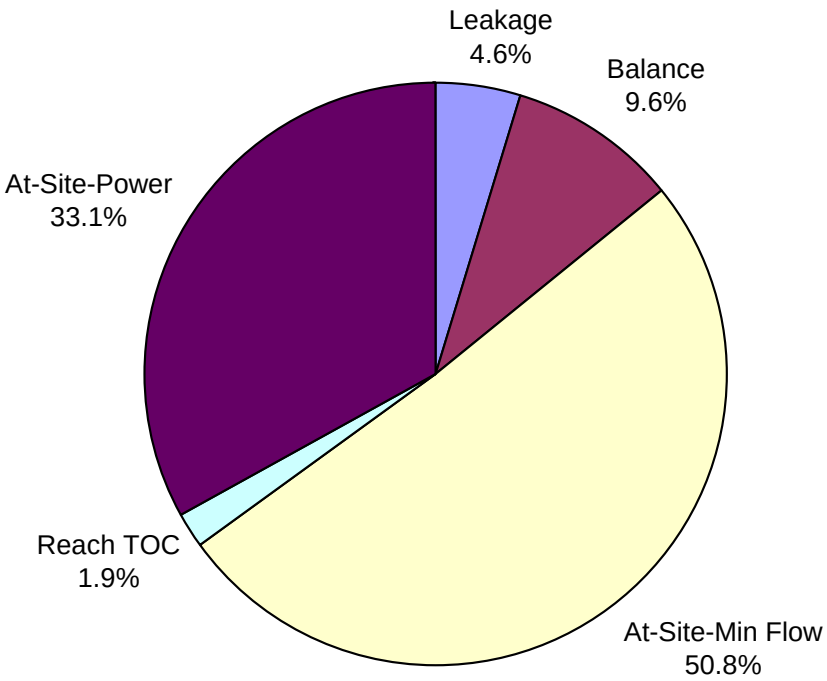
Concept 4

Buford Cases "Why Release Made"
Year 2000



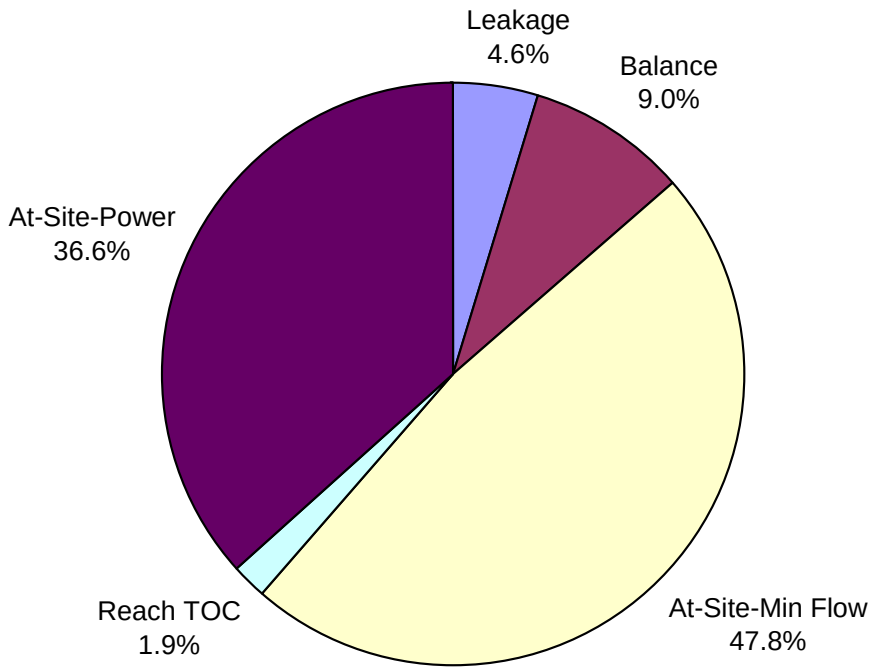
Concept 3

West Point Cases "Why Release Made"
Year 2000



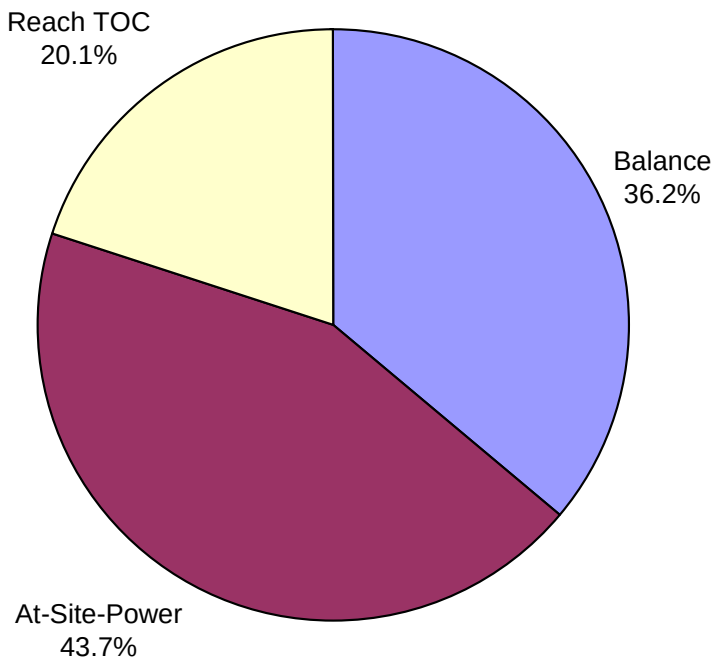
Concept 4

West Point Cases "Why Release Made"
Year 2000



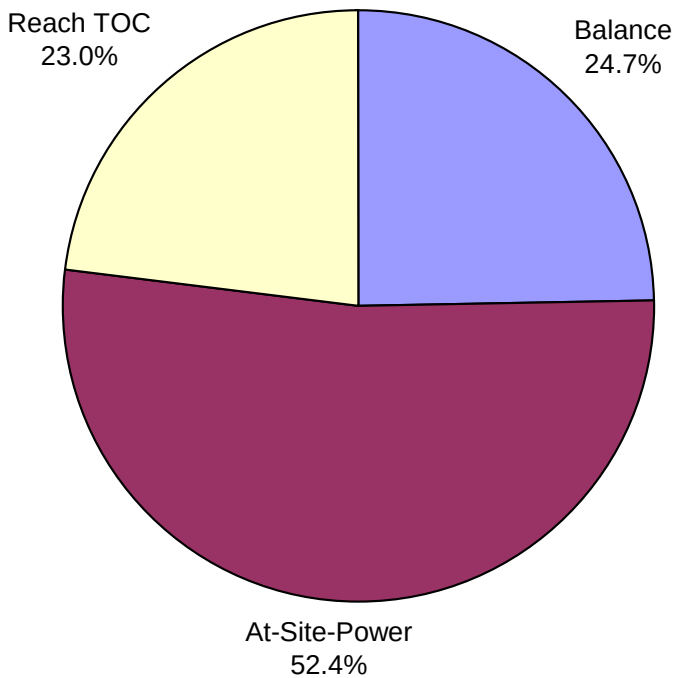
Concept 3

WF George Cases "Why Release Made"
Year 2000



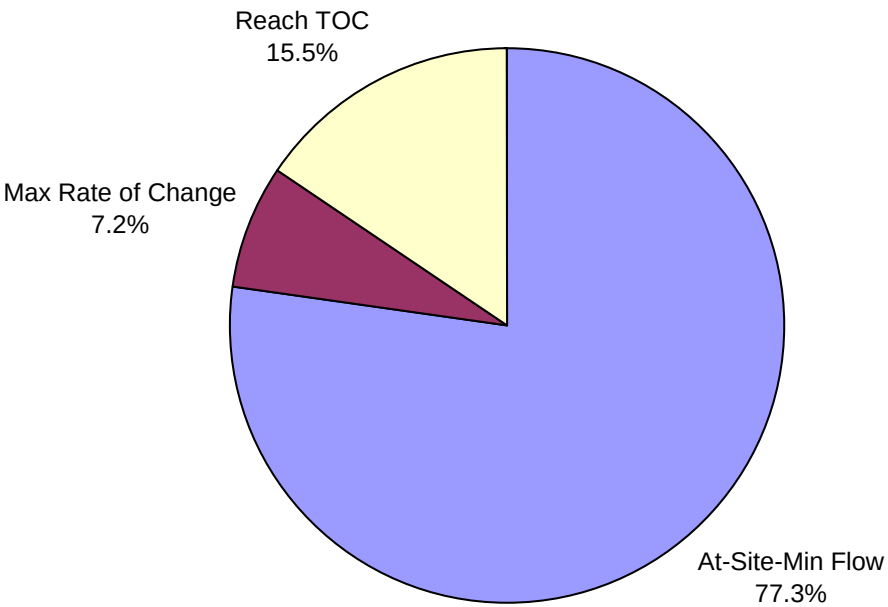
Concept 4

WF George Cases "Why Release Made"
Year 2000



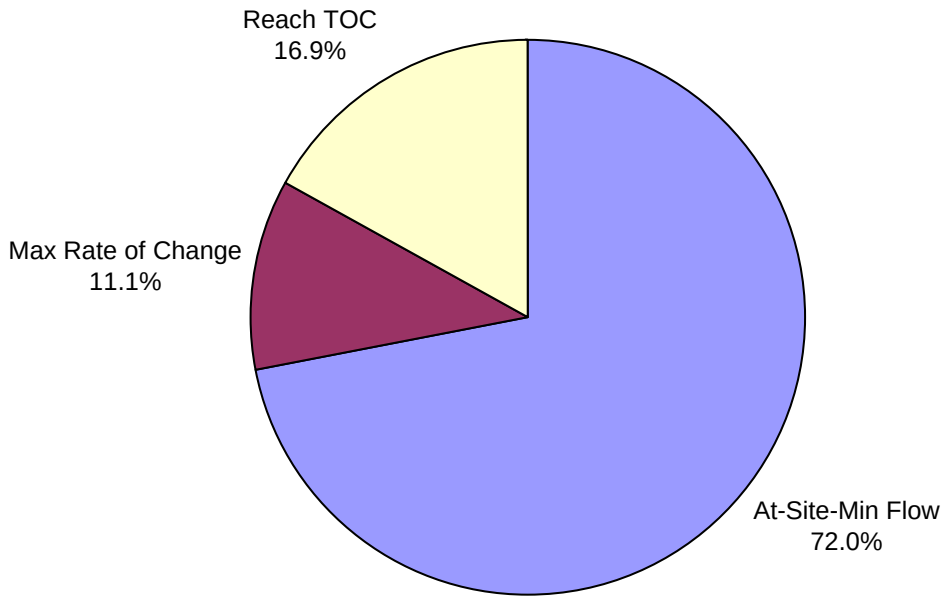
Concept 3

Jim Woodruff Cases "Why Release Made" Year 2000

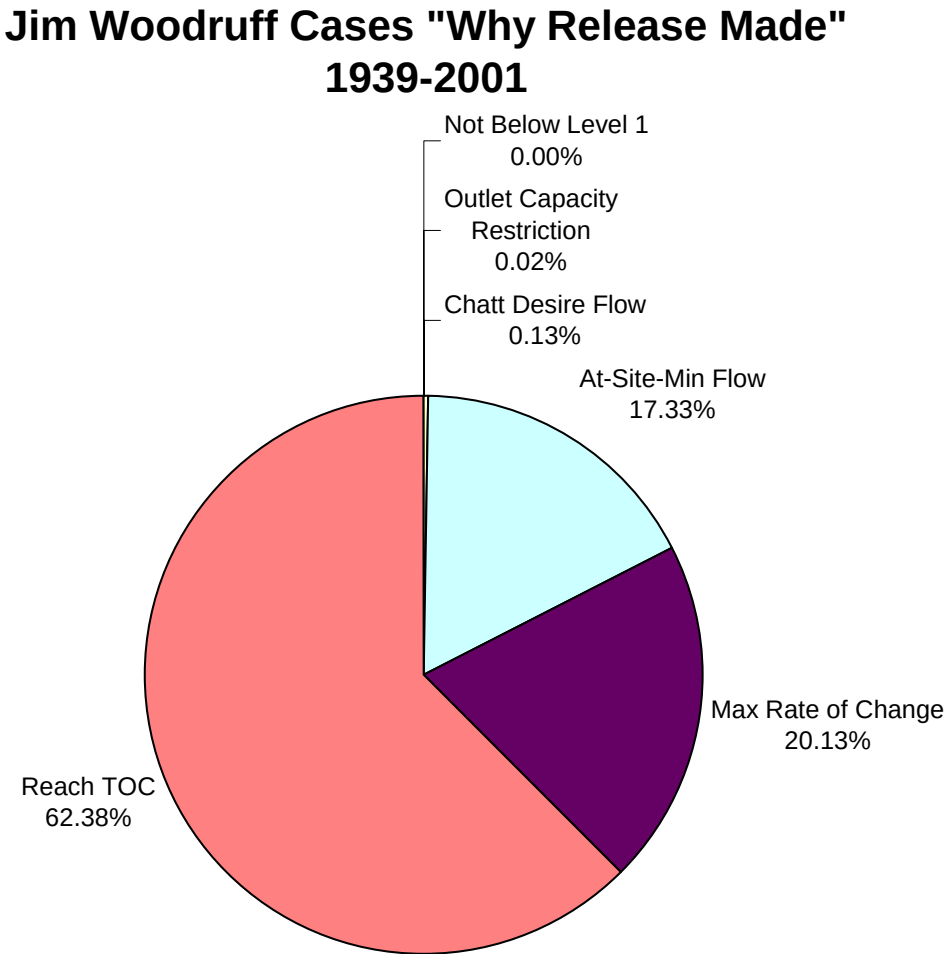


Concept 4

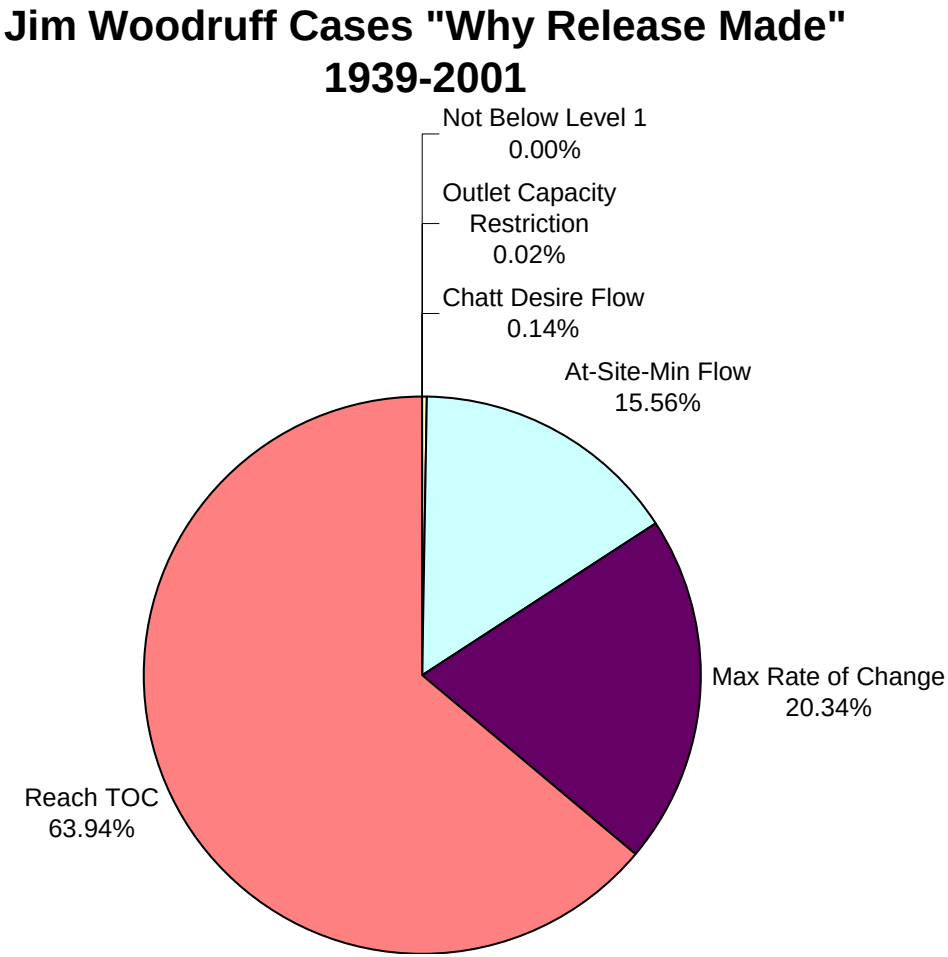
Jim Woodruff Cases "Why Release Made" Year 2000



Concept 3



Concept 4



Additional Work

- Model current IOP with composite trigger
- Investigate Flint River trigger