Southwestern Regional Hydropower Conference

Michael Biggs, PE

Chief, Reservoir Control Section

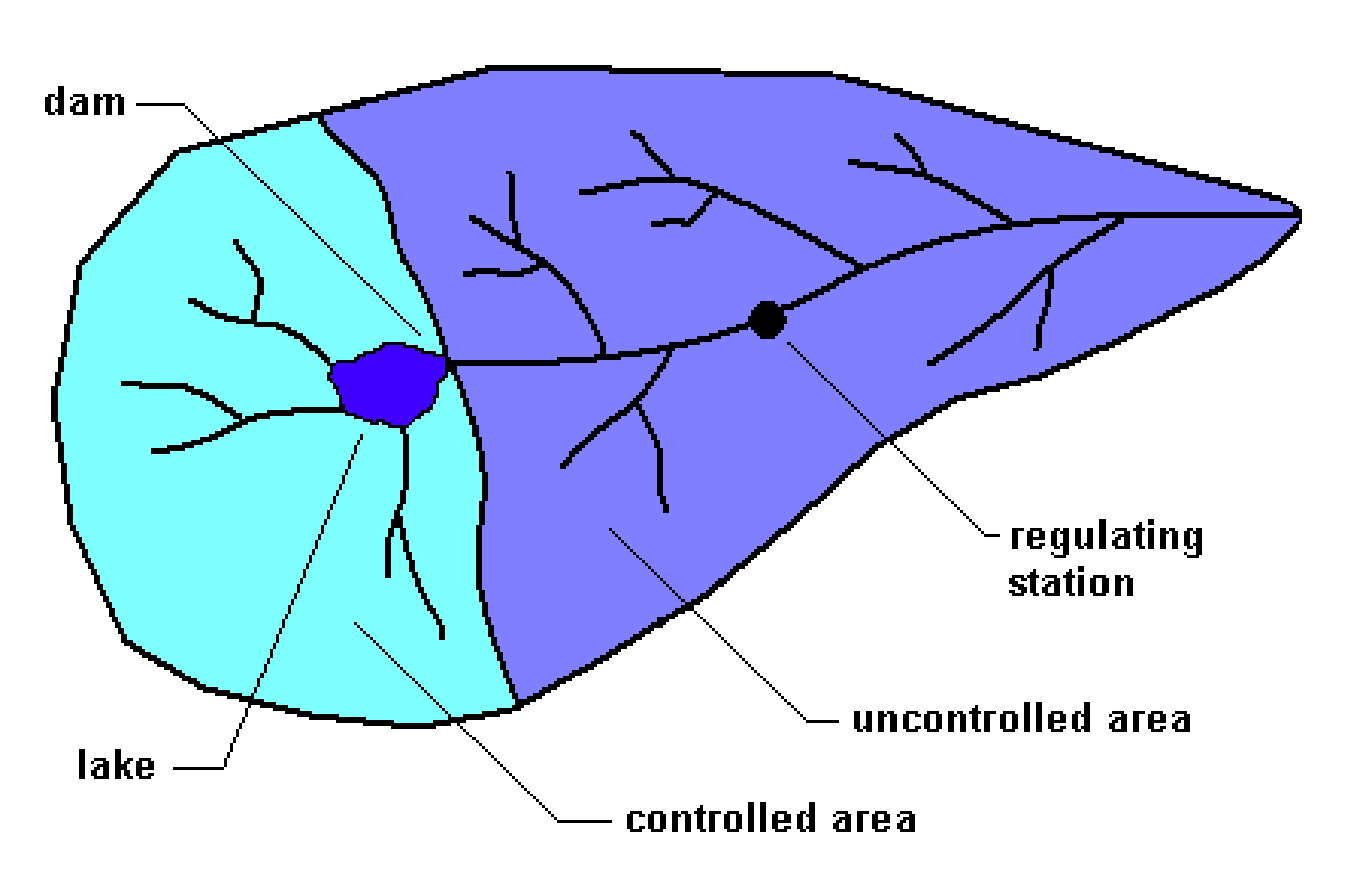
Hydraulics & Technical Services Branch

Little Rock District

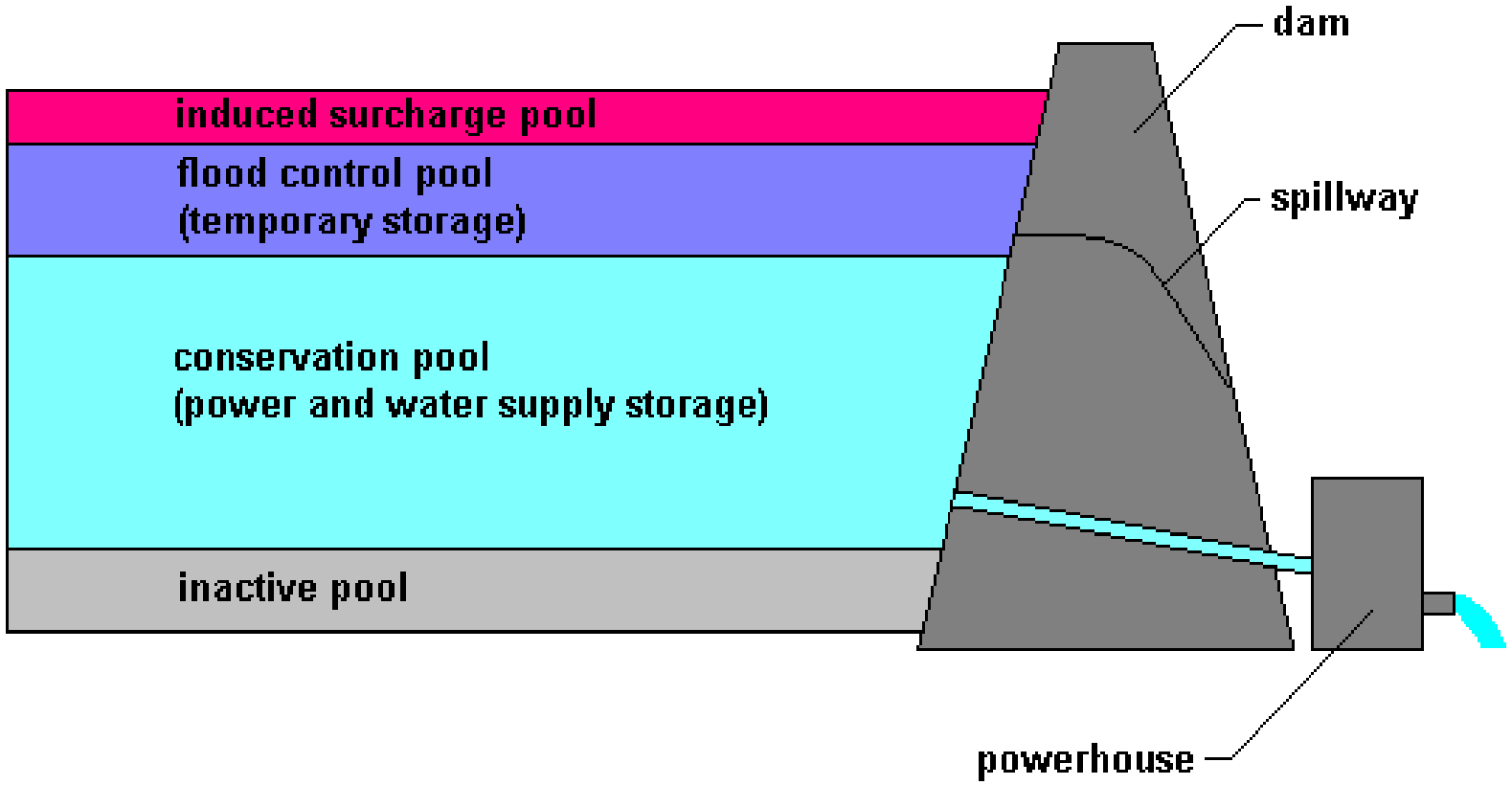
16 June 2011

White River Operations

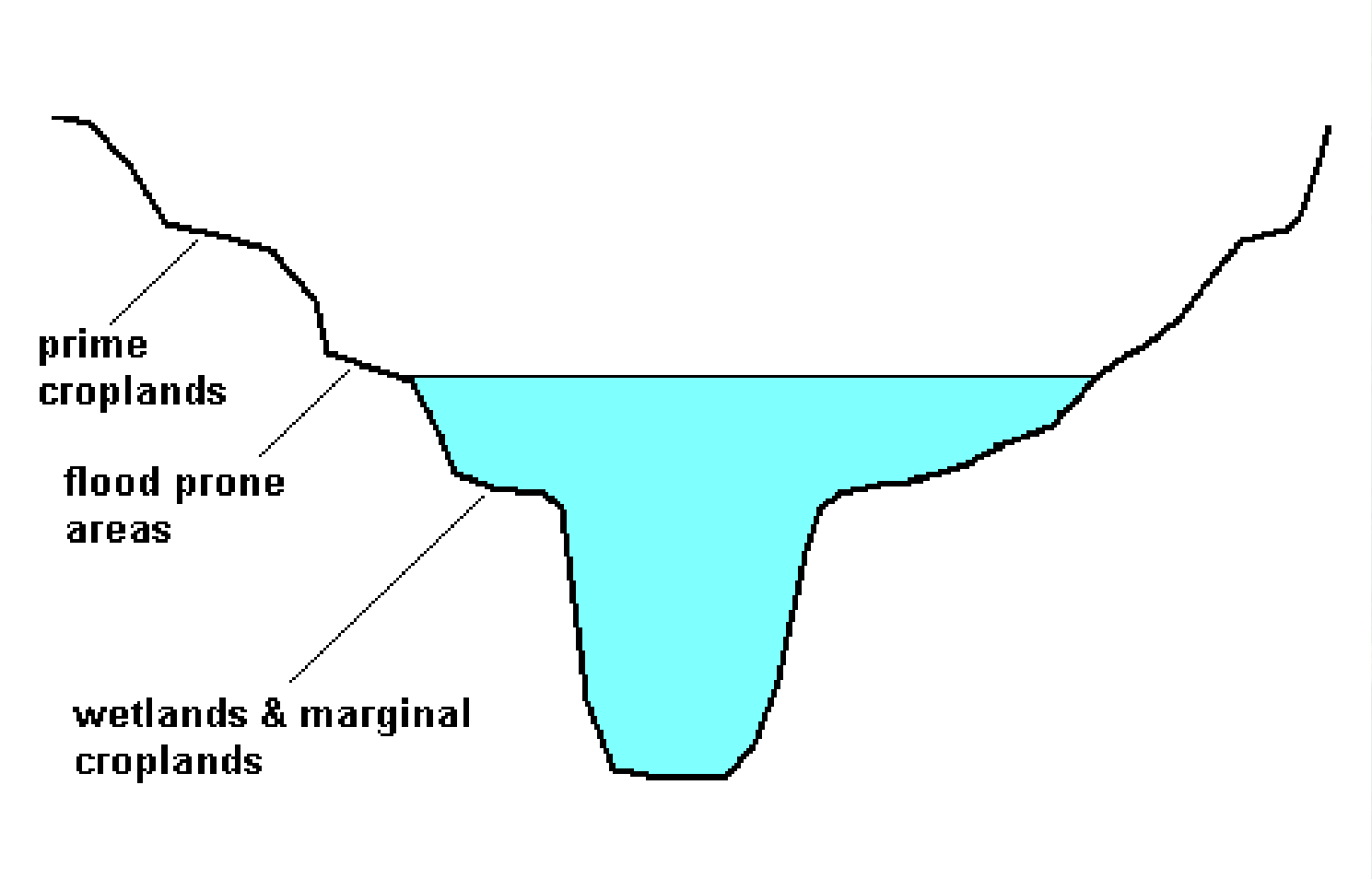
Typical River Basin



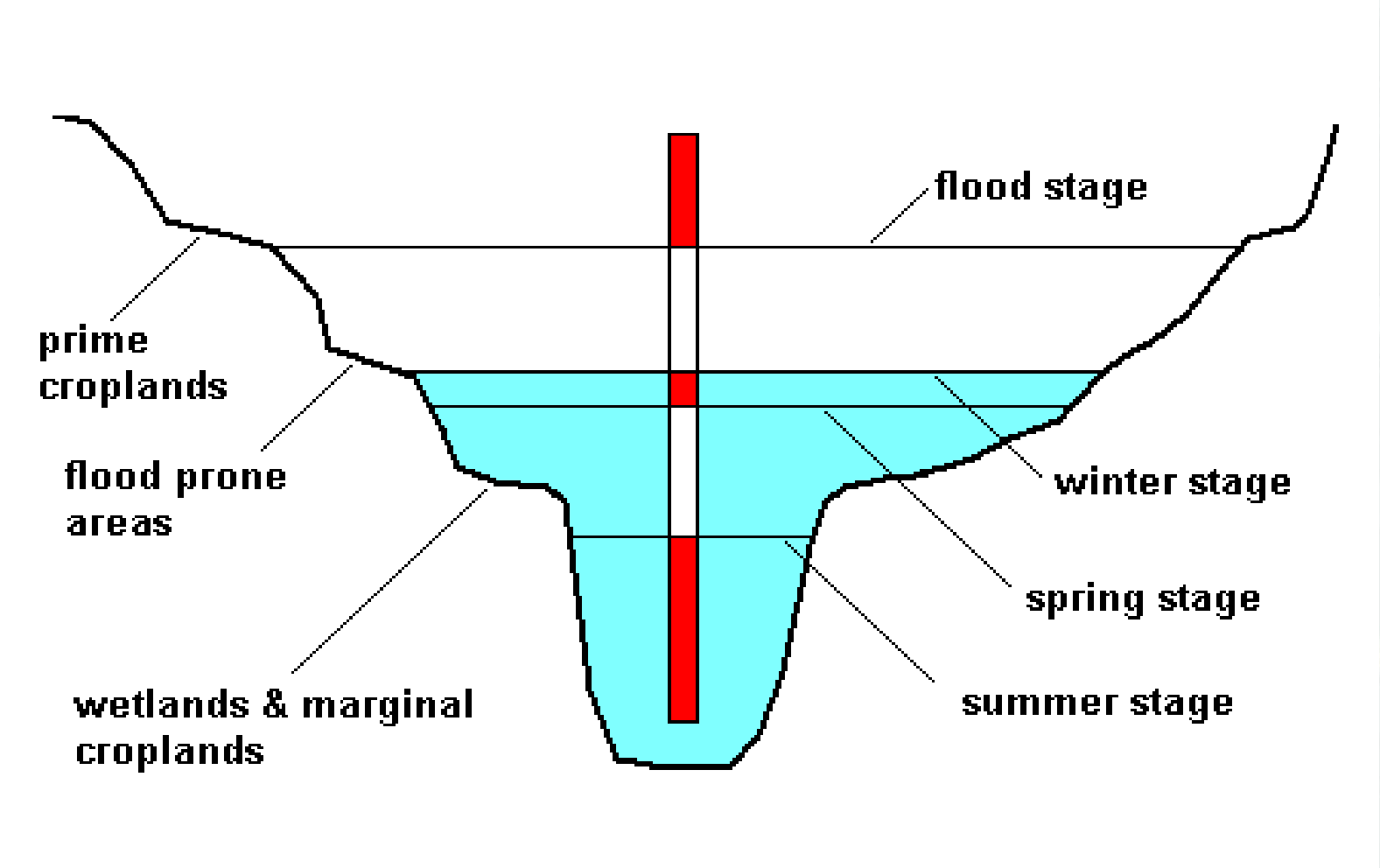
Typical Multi Purpose Project



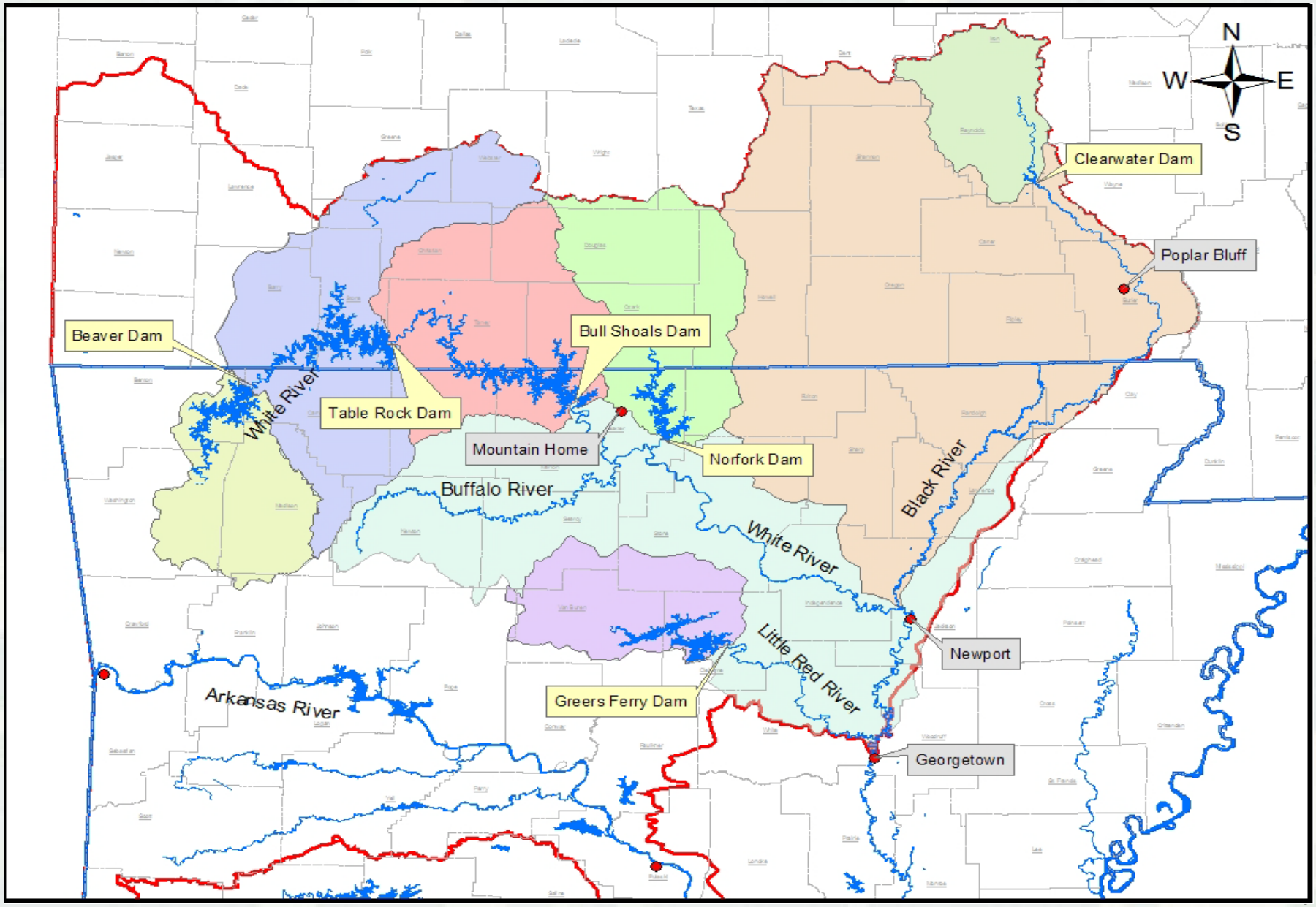
Typical River Section



Typical Regulating Station



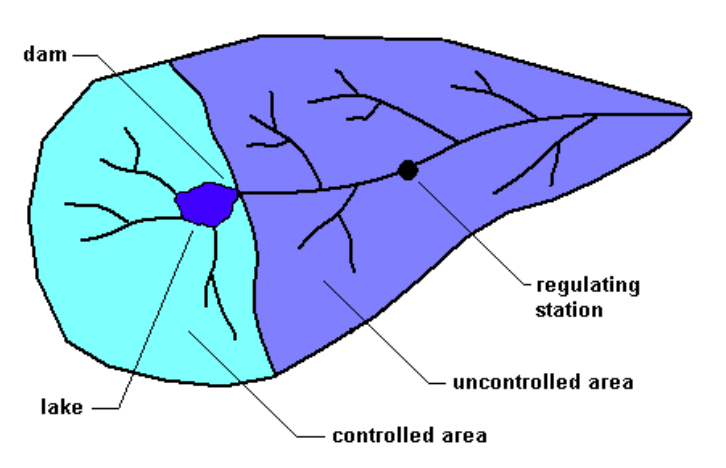
White River Basin and Projects



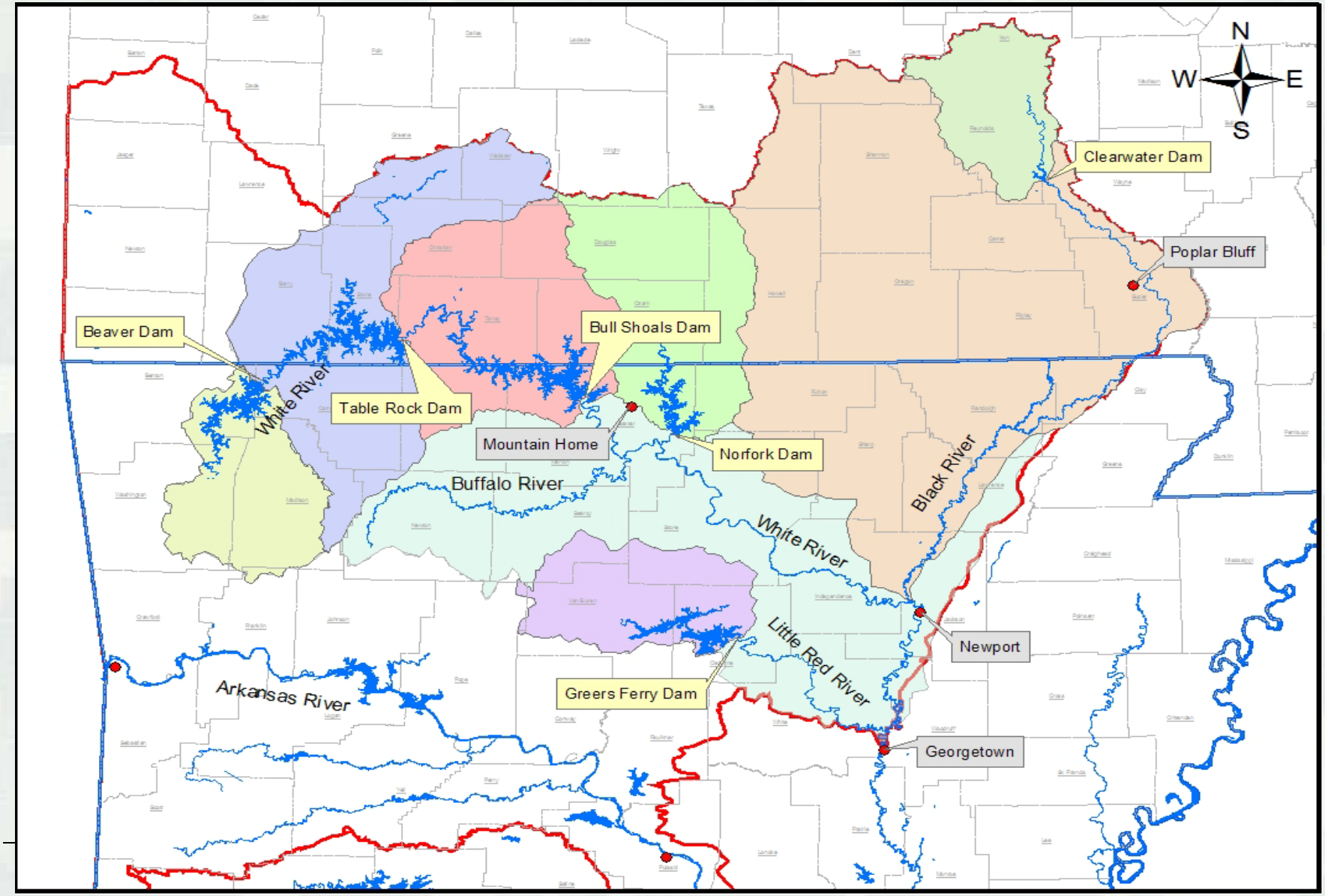
White River System

- Operated as a SYSTEM of reservoirs
  - Beaver, Table Rock, Bull Shoals, Norfork are a 4-lake subsystem
  - Greers Ferry
  - Clearwater
- "Comprehensive" system of water control regulation
  - encompasses the entire White River basin
  - 1 water control plan
- Operation of the system is VERY COMPLEX
  - vast basin—approximately 27,818 square miles
  - diversity among its users
    - Small businesses
    - Riverside residential areas & communities
    - In-lake & tailwater recreation
    - Agriculture
    - Navigation
    - Environmental

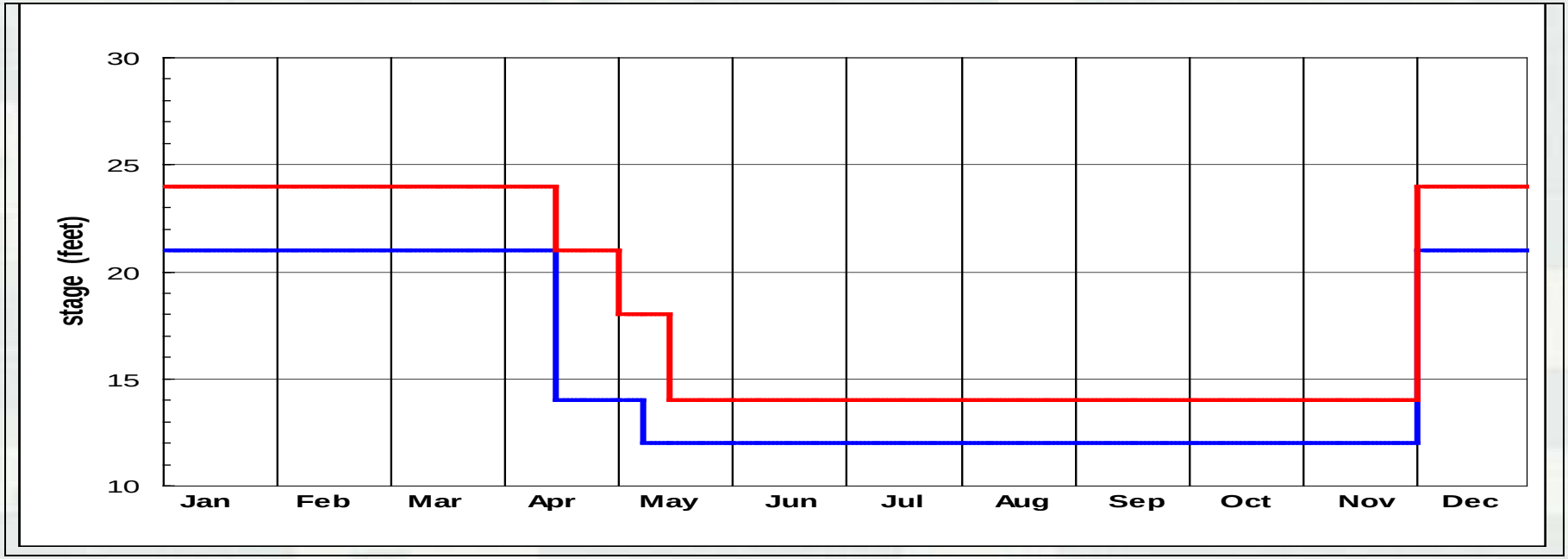
White River Downstream Regulating Stages



White River Basin and Projects



Newport Regulating Stages



1 Dec thru 15 Apr - regulate to higher of 21 ft or natural crest up to 24 ft

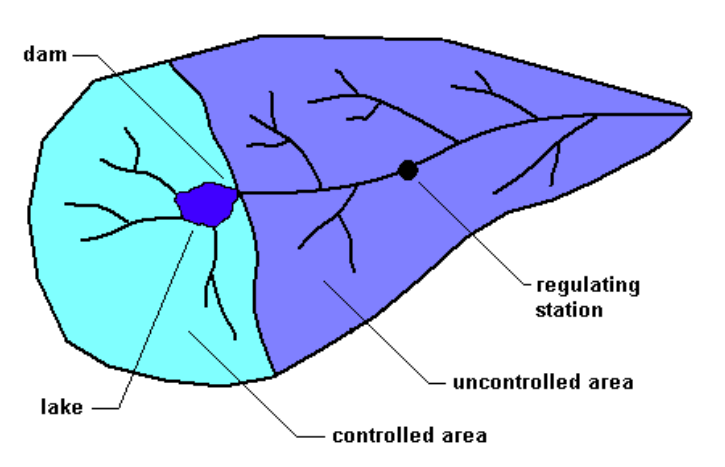
15 Apr thru 1 May - regulate to 14 ft, UNLESS 4-lake system storage is greater than 50% full, then regulate to 21 ft

1 May thru 7 May - regulate to 14 ft, UNLESS 4-lake system storage is greater than 50% full, then regulate to 18 ft

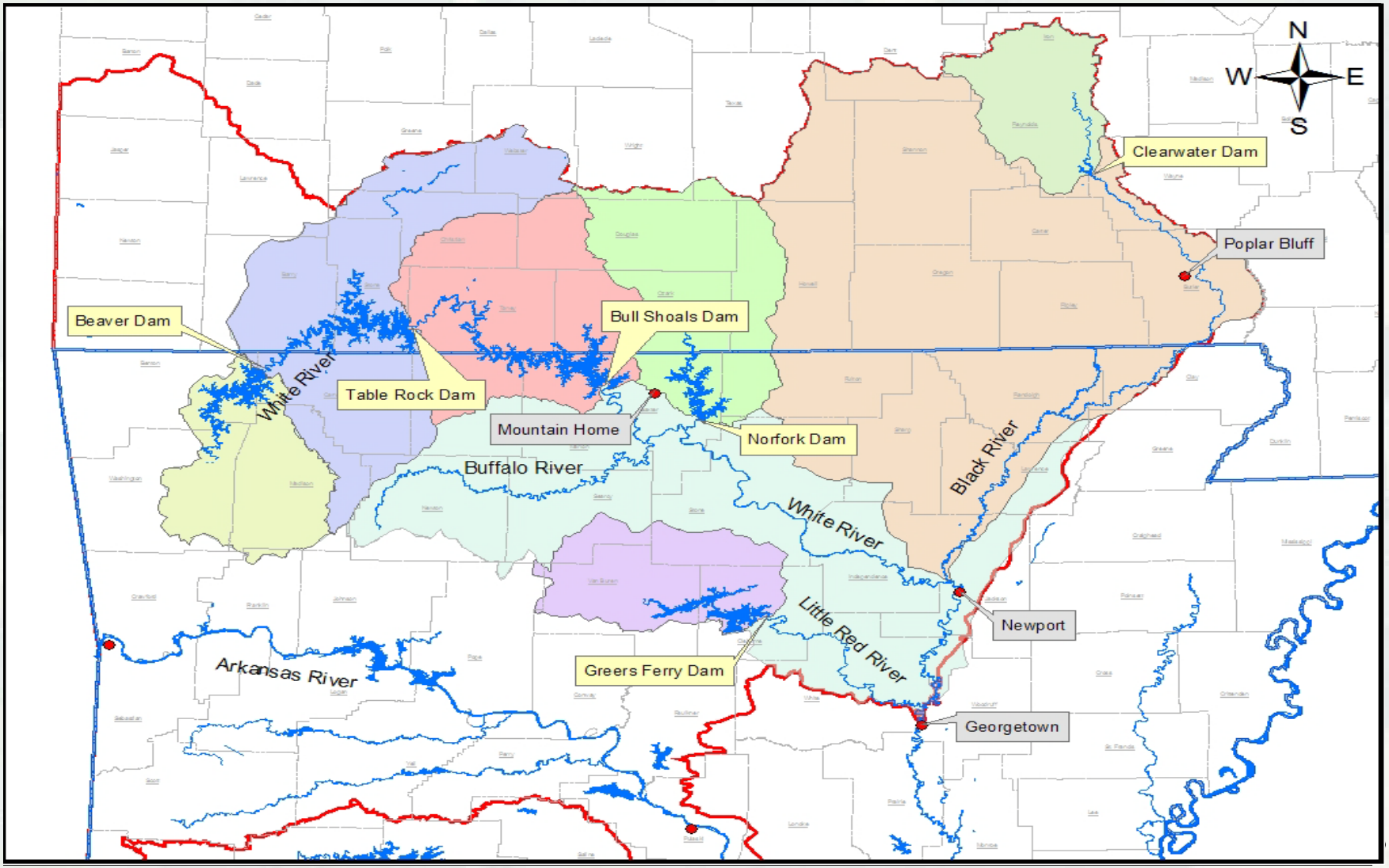
7 May thru 15 May - regulate to 12 ft, UNLESS 4-lake system storage is greater than 50% full, then regulate to 14 ft

15 May thru 1 Dec - regulate to 12 ft, UNLESS 4-lake system storage is greater than 70% full, then regulate to 14 ft

White River Projects Upstream Operations



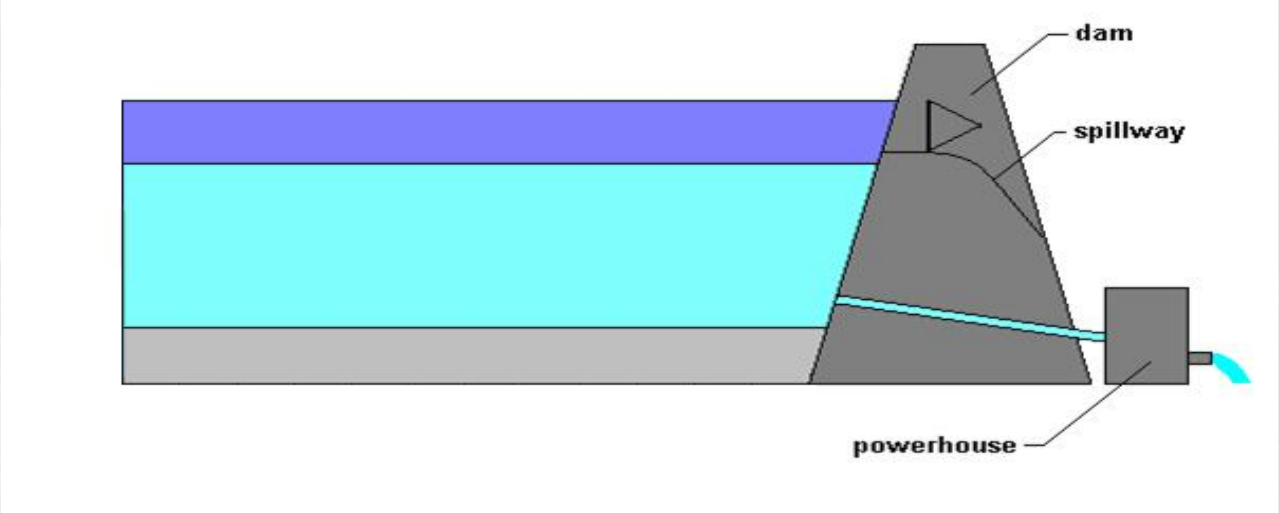
White River Basin and Projects



BUILDING STRONG®

When in Flood Control Pool

- Release at any given project is subject to downstream conditions
- The downstream condition is either a lake or downstream seasonal regulating river stage.
- Release subject to seasonal requirements for in stream flow needs (temperature and dissolved oxygen for trout fishery).



Summary of Regulation Criteria

Beaver Dam: Provide an increment of storage for Table Rock for protection of the local reach immediately downstream & for Bull Shoals for flood regulation on the lower White River

- Hold water if more than 2 ft of flood control storage is in use at Table Rock OR Bull Shoals.
- Limit release to firm power (950 dsf; 332mwh)

Table Rock: Provide storage for protection of local reach immediately downstream

- If Bull Shoals is below elevation 684.0, Release 15,000 cfs (< 920 ft) or 20,000 cfs (> 920 ft)
- If Bull Shoals is at or above elevation 684.0, limit release to maintain equal volume of remaining flood control storage in Table Rock & Bull Shoals.
- Subject to the minimum release required for firm power (2,550 dsf; 943 mwh)

Bull Shoals & Norfork Dams: Provide flood regulation on the lower White River

- Releases are controlled by the Newport Guide Curve
- When White River exceeds seasonal regulating stage, curtail releases to firm power at Bull Shoals (3,750 dsf; 1,352 mwh) & Norfork (1,300 dsf; 410 mwh).
- 6 days after the flood crest at Newport, begin secondary power releases while maintaining receding stages at Newport until seasonal regulating stage is achieved
- Prorate releases from Bull Shoals and Norfork to maintain equal percentages of available storage in the 3-lake sub-system (BV-TR-BS) and Norfork. Provides best flood regulation.

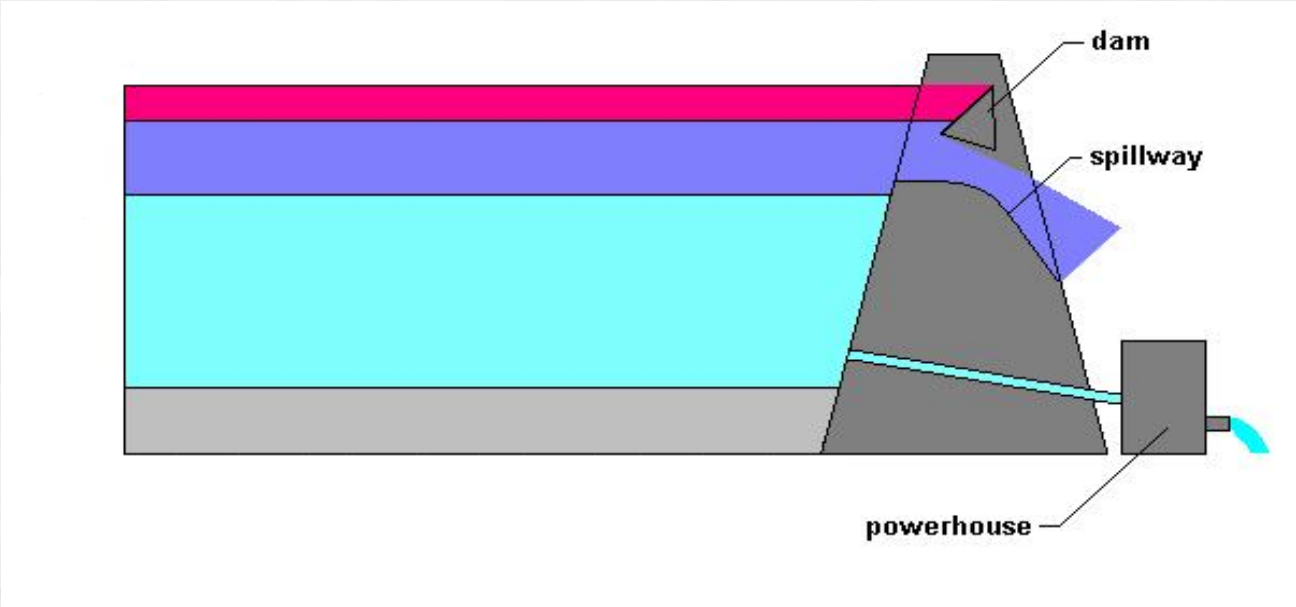
Greers Ferry Dam: Releases are made based upon the seasonal regulating stage at Georgetown for flood regulation of the lower White River.

- Subject to a minimum release of 3,000 cfs.

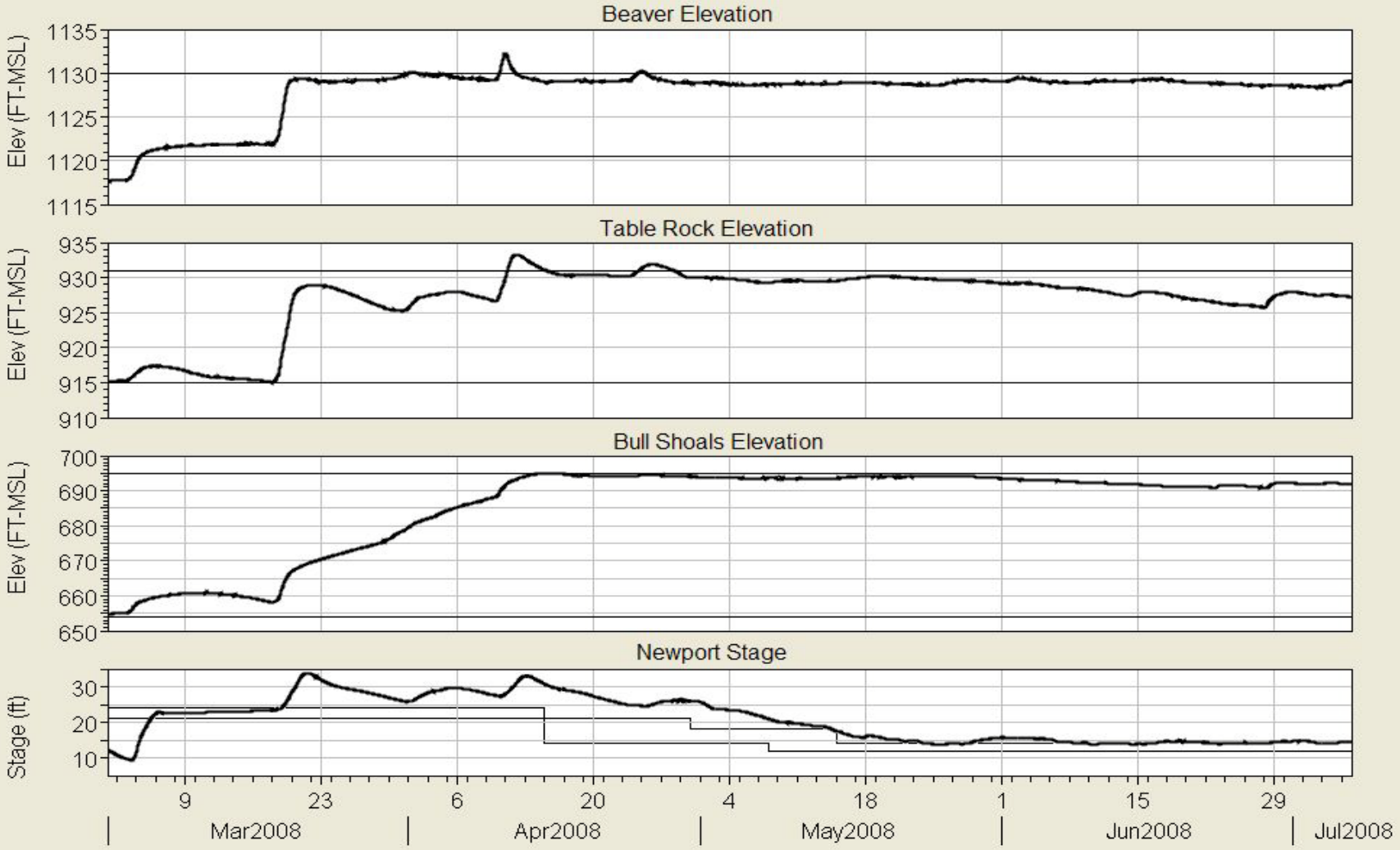
When Above or Forecasted to Rise *Above* Top of Flood Pool

- Regulate to obtain the most effective flood modification with the designated surcharge storage space.

- Object is to minimize peak pool AND peak discharge

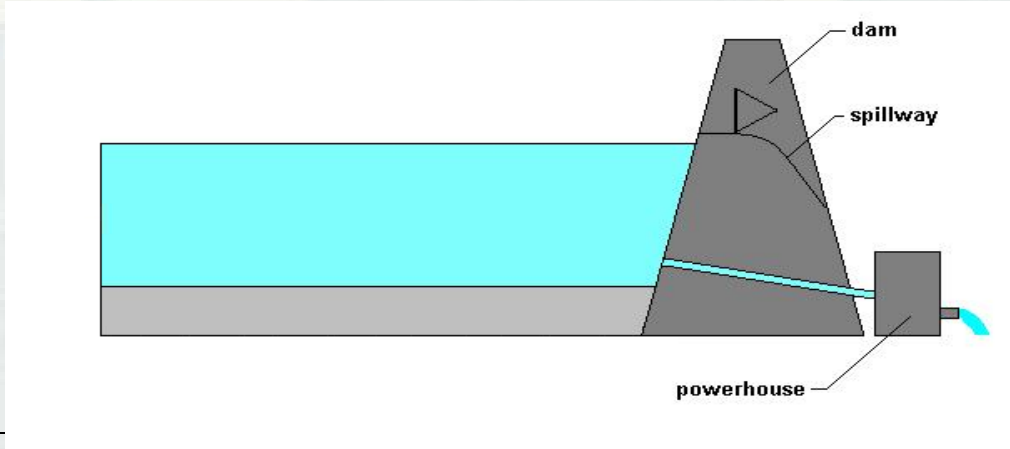


Flood of 2008



When in Conservation Pool

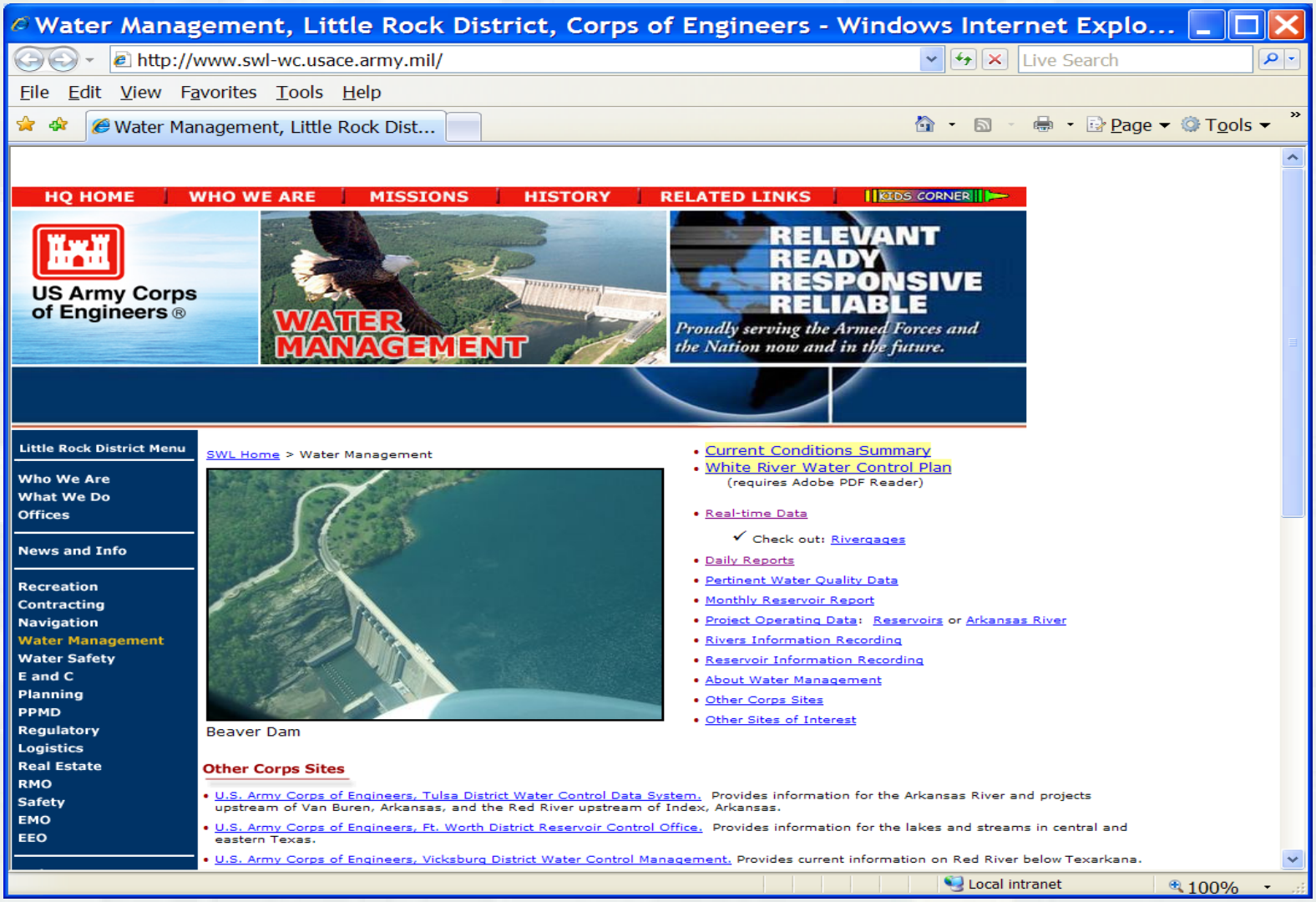
- Release subject to downstream conditions (downstream lake or downstream seasonal regulating stage).
- Hydropower release subject to allowable 7-day and 28-day drawdown limits.
- Release subject to seasonal requirements for instream flow needs (temperature and dissolved oxygen for trout fishery).
- Account for water supply withdrawals.



Competing Interests

Special Interest	Desirable Conditions
Flood Damage Reduction	Releases are unencumbered; releases made as d/s conditions permit. Pool fluctuates considerably
Hydropower	Generate as needed without restriction. Pool is drawn down.
Water Supply Withdrawal	Withdraw as much water as needed, without depleting storage
Minimum Flows	Steady minimum release 24/7
Environmental	Discharge does not impair water body; DO > 6 ppm & Temp < 65°
Lakeside Concessionaires	Flat pool; little fluctuation; minimum drawdown; facilities available
D/S Concessionaires	Steady flow for float fishing
D/S fishermen	Release enough for temp control, but not prevent wade fishing
D/S Farmers	River less than12 ft @ Newport
Navigation	Continual, steady release (higher than fishermen desire)
Duck Hunters	Hold water in summer, dump during the winter
Lake Homeowners	Flat pool; little fluctuation;
D/S Homeowners	Live on river w/o risk of flooding
Lake Recreation	“Normal” pool elevation
Special Interest Groups	“Special” conditions on an as needed basis

Sources of Information



http://www.swl-wc.usace.army.mil

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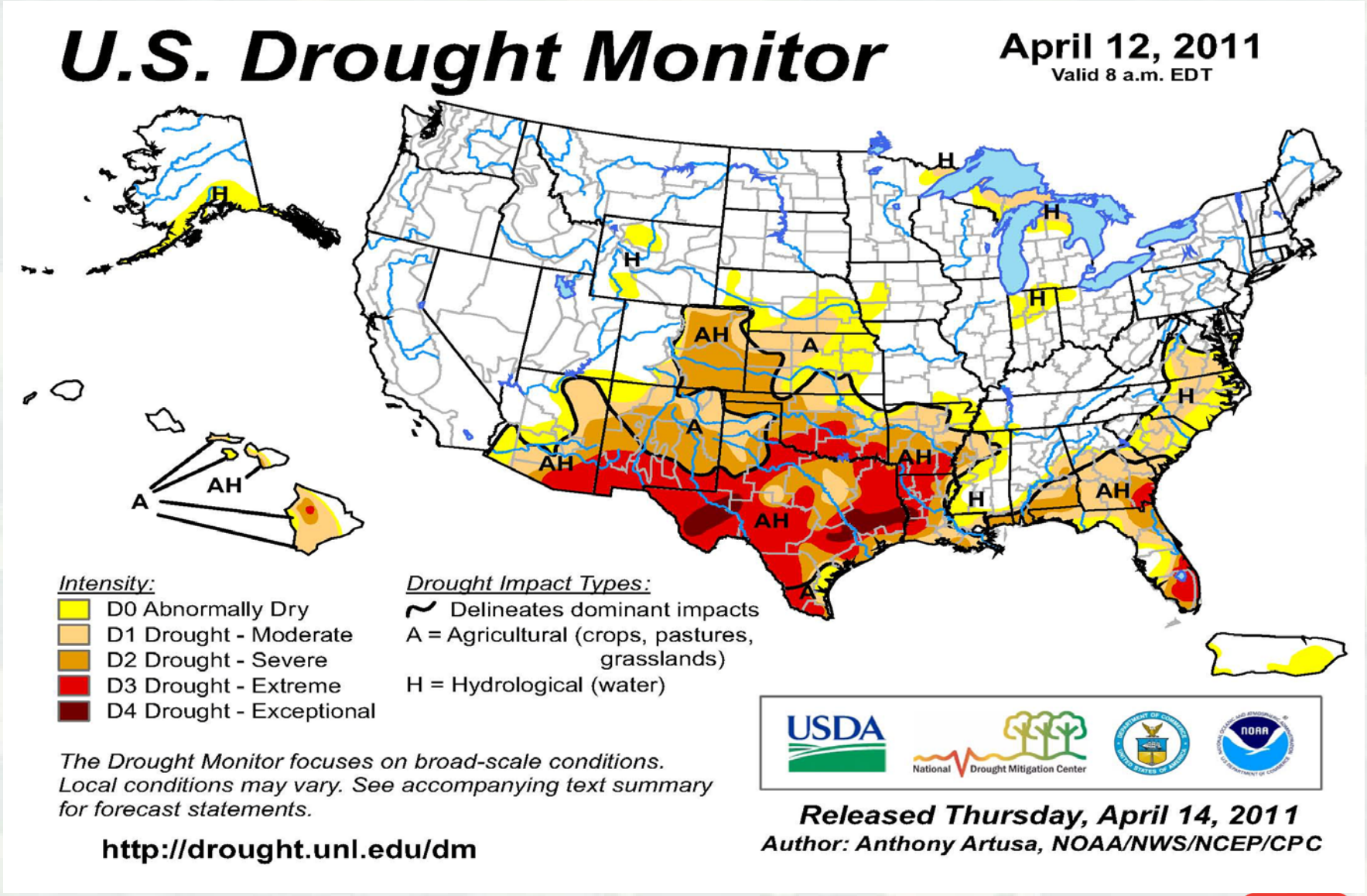
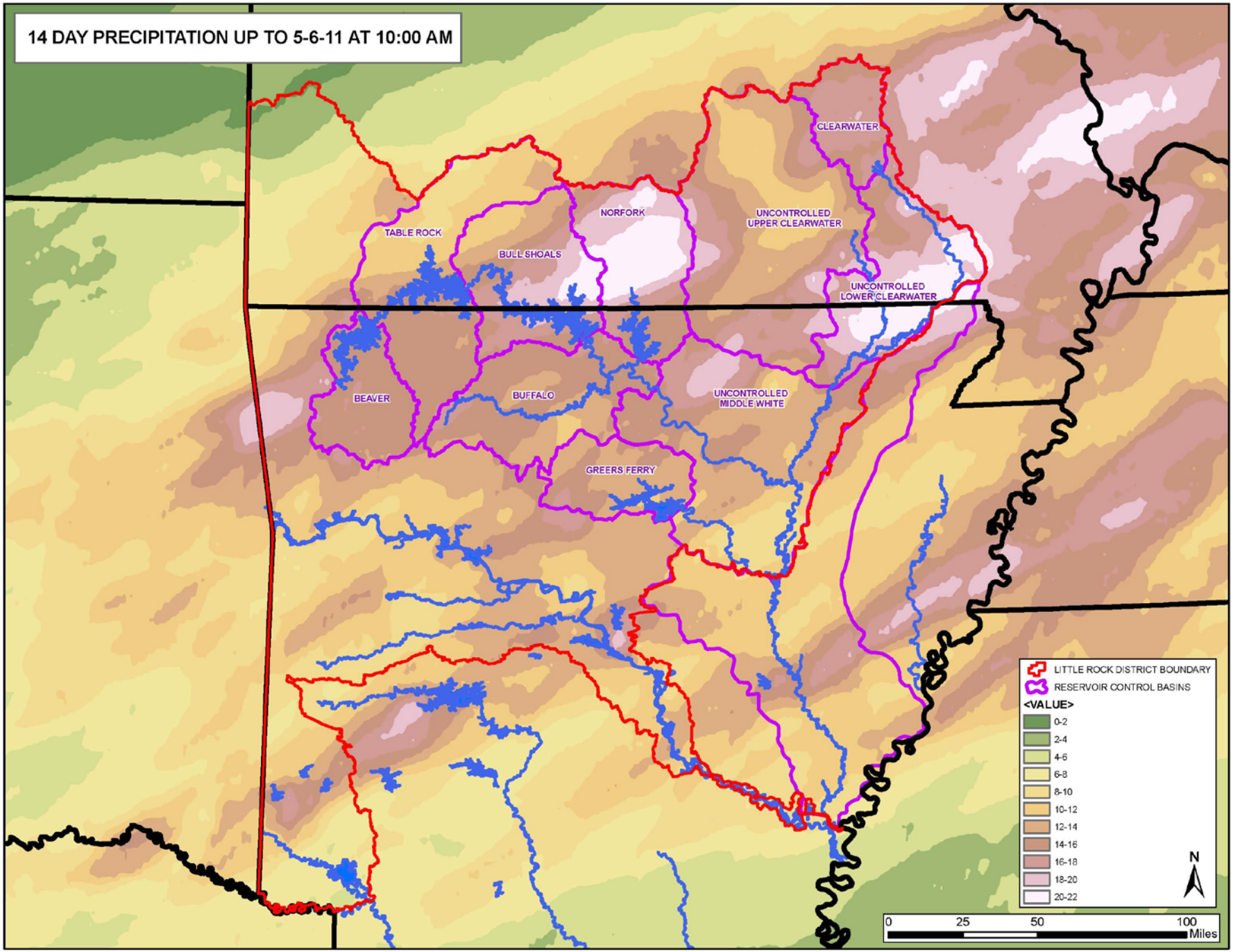
Spring 2011 Flood


U.S. Drought Monitor
April 12, 2011
Valid 8 a.m. EDT
Intensity:
D0 Abnormally Dry
D1 Drought - Moderate
D2 Drought - Severe
D3 Drought - Extreme
D4 Drought - Exceptional
Drought Impact Types:
Delineates dominant impacts
A = Agricultural (crops, pastures, grasslands)
H = Hydrological (water)
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.
http://drought.unl.edu/dm
USDA
National Drought Mitigation Center
NOAA
Released Thursday, April 14, 2011
Author: Anthony Artusa, NOAA/NWS/NCEP/CPC


14 DAY PRECIPITATION UP TO 5-6-11 AT 10:00 AM
CLEARWATER
NORFORK
UNCONTROLLED UPPER CLEARWATER
TABLE ROCK
BULL SHOALS
UNCONTROLLED LOWER CLEARWATER
BEAVER
BUFFALO
UNCONTROLLED MIDDLE WHITE
GREERS FERRY
LITTLE ROCK DISTRICT BOUNDARY
RESERVOIR CONTROL BASINS
<VALUE>
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12-14
14-16
16-18
18-20
20-22
N
0
25
50
100
Miles

Rainfall Comparisions

DAM	Average April Rain	Rainfall 22-28 April	Rainfall April 2011	Rainfall April 2008
Beaver	4.5 in	11.57 in	15.1 in	9.16 in
Table Rock	4.1	10.43	13.6	7.90
Bull Shoals	3.9	12.06	15.3	7.90
Norfork	4.1	13.23	16.8	8.15
Greers Ferry	4.9	7.4	10.6	9.21
Clearwater	4.5	11.31	14.01	9.16

Representative Observed Rainfall

April-May 2011

Station	Rain	Station	Rain
St Paul	26.14 in	Fayetteville	26.78 in
Deer	29.51	NW AR Reg Airport	23.05
Mountainburg	22.71	Eureka Springs	22.75
Taney	26.82	Protem	23.93
Taneyville	23.20	Lake Taneycomo	20.66
Emerald Beach	22.08	Branson/Bull Creek	17.65
Harrison	26.56	Beaver Creek	19.30
Mountain Home	30.89		
Gilbert	24.01	Jasper	21.50
Mountain View	28.20	Melbourne	29.86 in
Batesville Airport	26.13	Calico Rock	27.66
Batesville L&D	26.08	Evening Shade	25.96
Newport	24.45	Des Arc	24.60

Lake Level Comparision

DAM	Cons Pool	01 April*	Delta	Peak Elev
Beaver	1,120.43	1,113.94	- 6.5 ft	1,131.67
Table Rock	915.0	911.79	- 3.2	935.47
Bull Shoals	654.0	651.90	- 2.1	696.51
Norfork	552.0	549.01	- 3	580.95
Greers Ferry	461.44	458.46	- 3	481.41
Clearwater	494.0	495.08	+ 1	566.69

* 7 AM reading

How the Dams Did Their Jobs

(Inflow vs. Outflow)

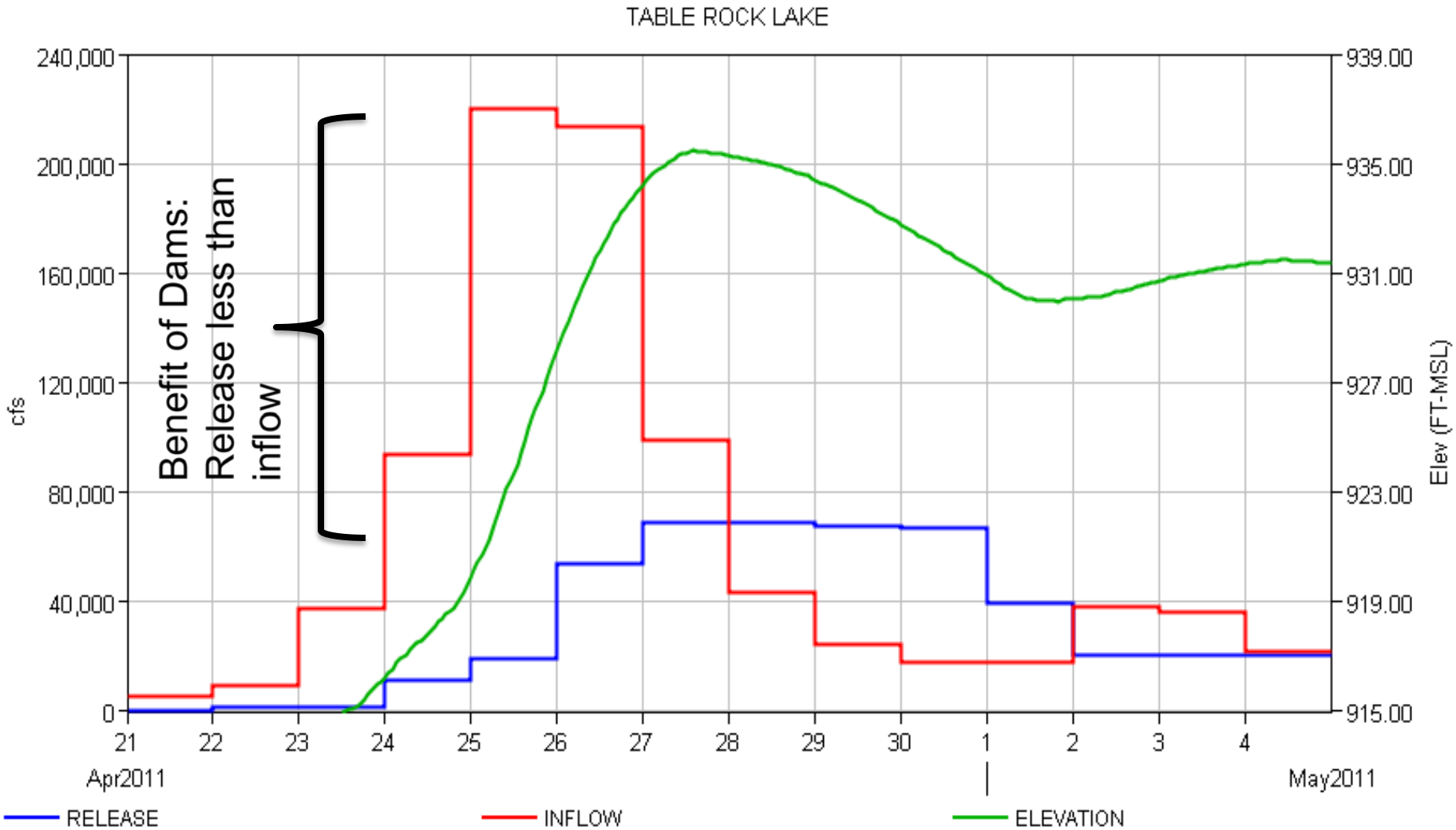
DAM	Peak Inflow	6-Hour Ave	Release
Beaver	175K	130-140K	70,000
Table Rock	290K	240-250K	68,000
Bull Shoals	440K	230-300K	3,850
Norfork	197K	120-170K	2,100*
Greers Ferry	152K	135K	3,000
Clearwater	63K	42K	150*

* Maximum release made during the initial rise of the lake. Norfork released 36,000 cfs when the top of flood pool was exceeded and Clearwater released 4,000 cfs as the pool crested.

Estimated Stage Reduction

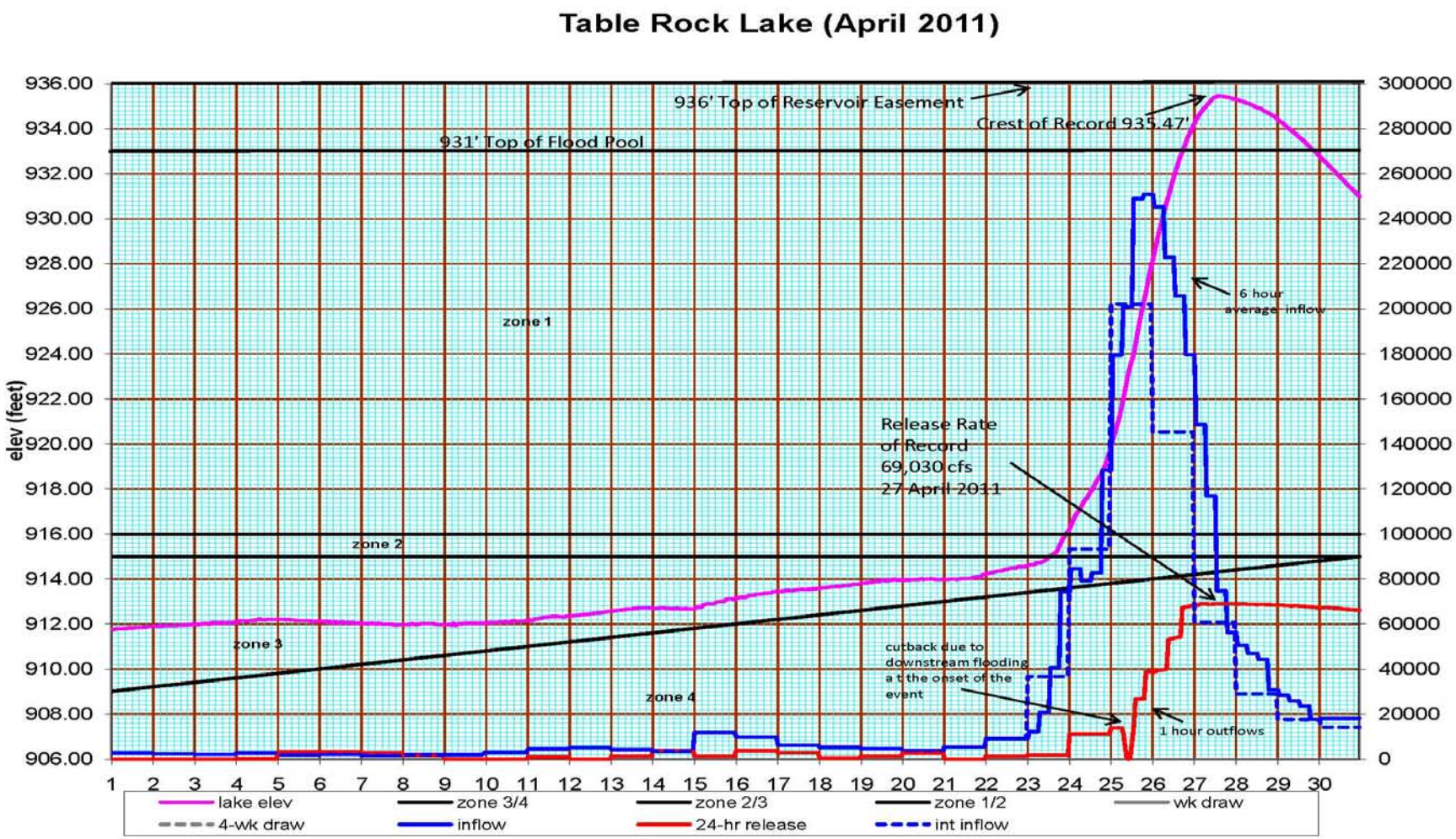
Gaging Station	Actual Stage	Est. Natural Stage	Dams Reduced Stage By
Branson			~ 20 ft
Powersite Dam	708.24 ft	721 ft	~ 13 ft
Calico Rock	29.28 ft	66 ft	~ 36 ft
Batesville	23.57 ft	45 ft	~ 21 ft
Newport	33.59 ft	41 ft +	> 7 ft
Augusta	38.35 ft	44 ft	> 5 ft
Georgetown	33.95 ft	45 ft	> 10 ft

Benefit of Dams: Release less than Inflow

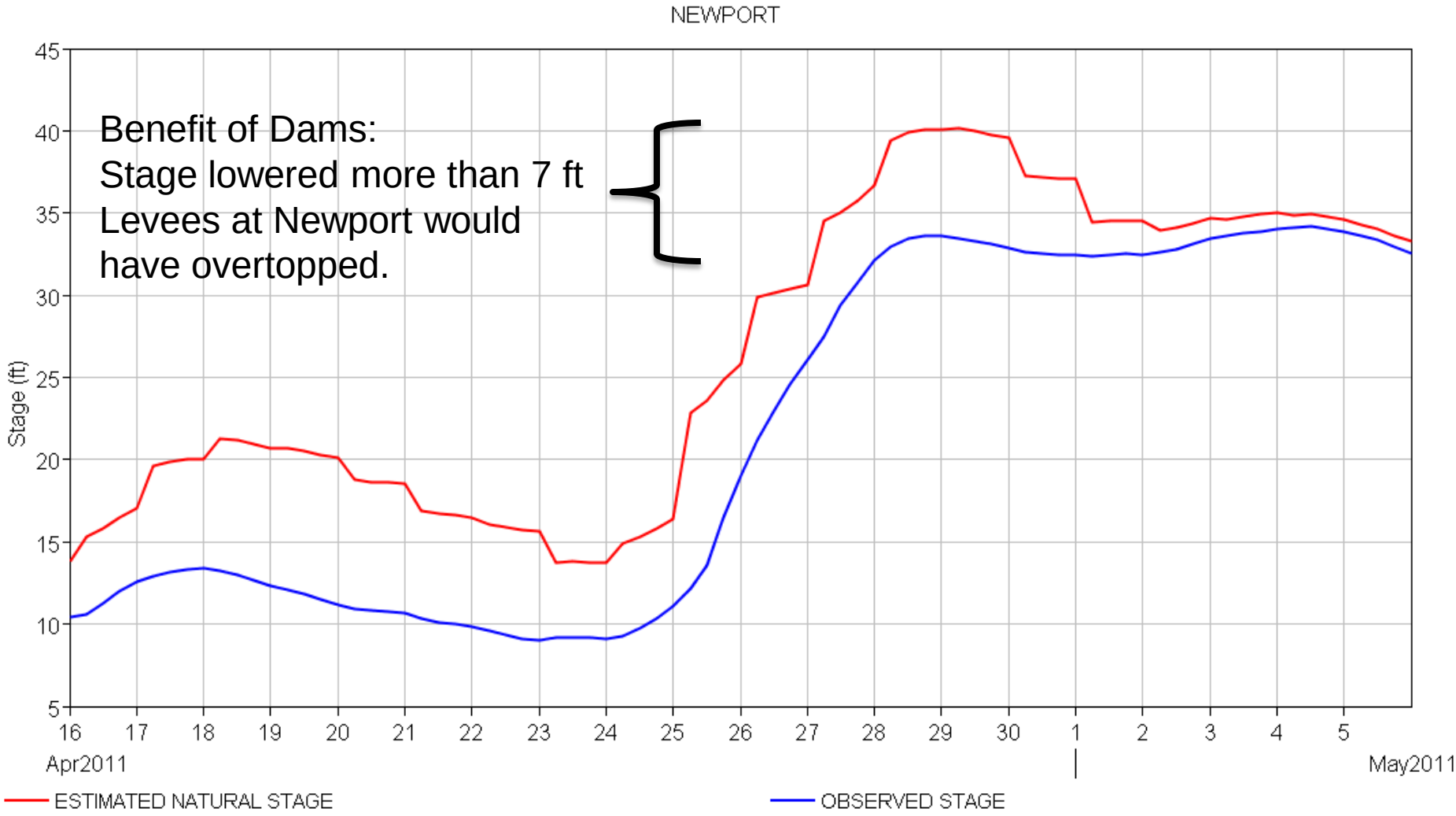


Benefit of Table Rock Dam was its capacity to store runoff from excessive rain that fell 4/21 to 4/27 so that the release from the dam never exceeded the inflow into the lake.

Benefit of Dams: Release less than Inflow



Benefit of Dams: Peak Stage is Lower



When Will The Lakes Be Lower?

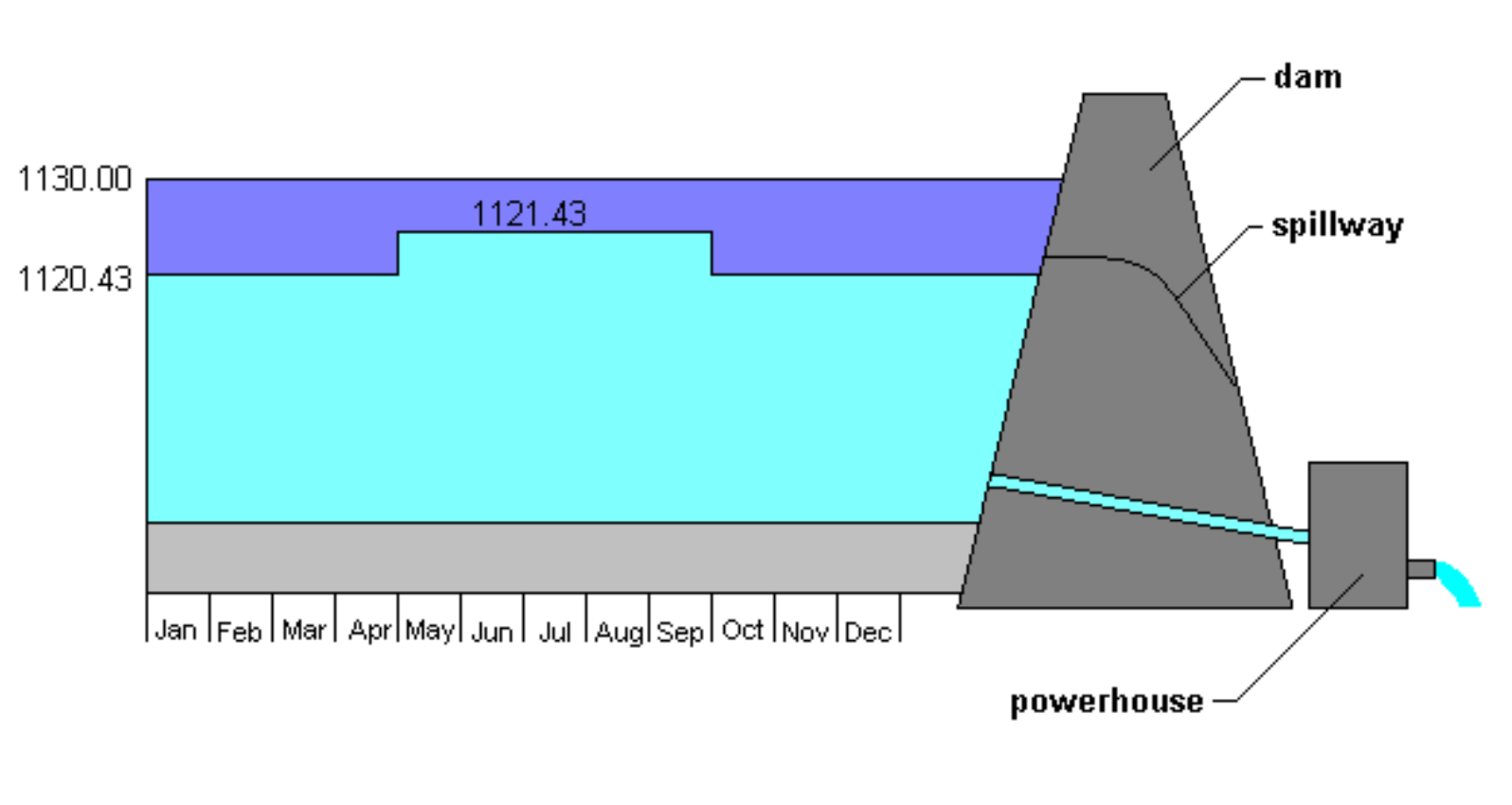
DAM	June 1	July 1	Aug 1	Empty
Beaver	1,129	1,128	1,128	end-Dec
Table Rock	927	924	920	mid-Aug
Bull Shoals	690	685	680	mid-Dec
Norfork	578	575	572	mid-Dec
Greers Ferry	482	475	465	mid-Aug
Clearwater	555	530		mid-July

Assumes zero appreciable rainfall
Empty dates estimated from the 2008 Flood Event slipped 2 weeks

Questions

Supporting Slides
Detailed Regulating Criteria
White River System

Beaver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1120.43
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powerhouse

Beaver Regulation Criteria

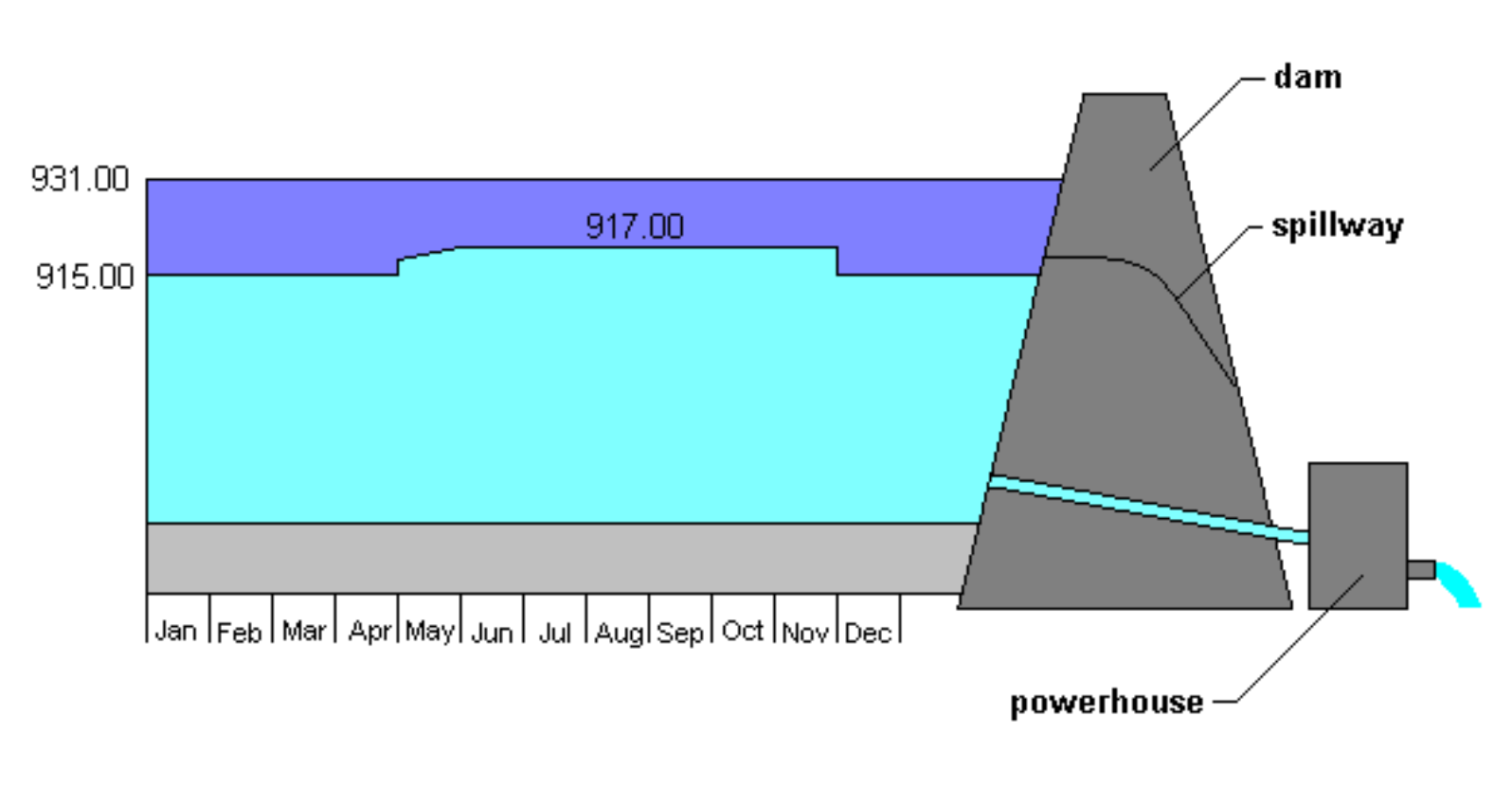
- **Beaver flood releases (from elevation 1120.43 to 1130.00)**
  - If more than 2 feet of flood control storage is in use at Table Rock OR Bull Shoals
    - Limit release to firm power (950 dsf; 332mwh)
  - If less than 2 feet of flood control storage is in use at Table Rock AND Bull Shoals
    - Target release to maintain falling pool at Beaver without causing a rising pool at Table Rock
  - If no flood control storage is in use at Table Rock AND Bull Shoals
    - Use combined spillway and turbine release up to the allowable Bull Shoals release LESS the intervening flow between Beaver and Bull Shoals
      - Not to exceed 15,000 cfs LESS the intervening flow between Beaver and Table Rock

Beaver Regulation Criteria

(continued)

- **Beaver flood releases (above elevation 1130.00 or predicted to exceed 1130.00)**
  - Let outflow equal inflow when flood pool fills, subject to the use of surcharge storage to reduce peak discharges and delay inflow to Table Rock

Table Rock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powerhouse

Table Rock Regulation Criteria

- **Table Rock flood releases (from elevation 915.0 to 920.0)**
  - If Bull Shoals is below elevation 684.0
    - Release 15,000 cfs
  - If Bull Shoals is at or above elevation 684.0
    - Limit release to maintain equal volume of flood control storage remaining between Bull Shoals and Table Rock
    - Subject to the minimum release required for firm power (2,550 dsf; 943 mwh)

Table Rock Regulation Criteria

(continued)

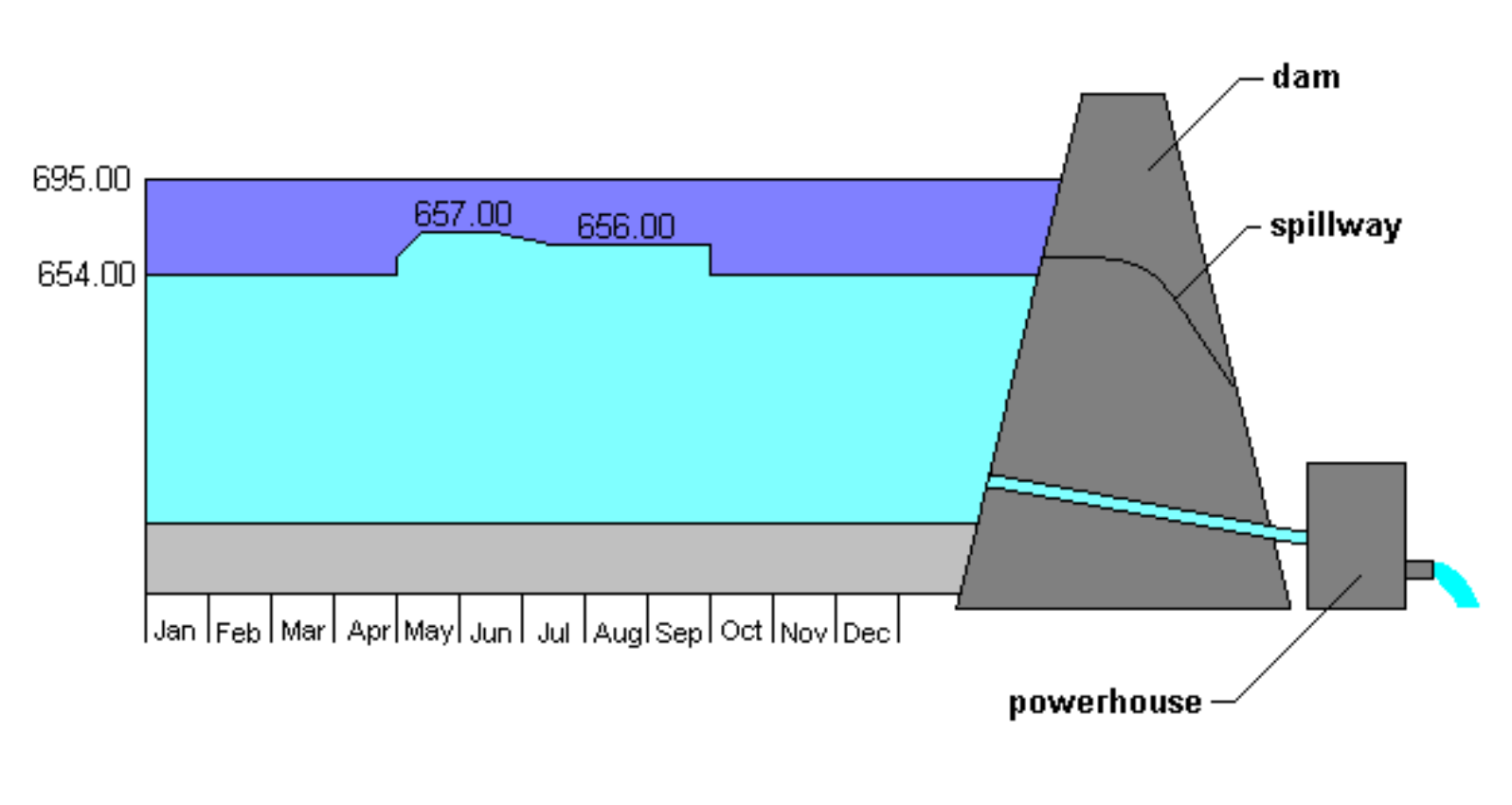
- **Table Rock flood releases (from elevation 920.0 to 931.0)**
  - If Bull Shoals is below elevation 684.0
    - Release 20,000 cfs
  - If Bull Shoals is at or above elevation 684.0
    - Limit release to maintain equal volume of flood control storage remaining between Bull Shoals and Table Rock
    - Subject to the minimum release required for firm power (2,550 dsf; 943 mwh)

Table Rock Regulation Criteria

(continued)

- **Table Rock flood releases (above elevation 931.0 or predicted to exceed 931.0)**
  - Regulate to obtain most effective flood modification with designated surcharge storage space

Bull Shoals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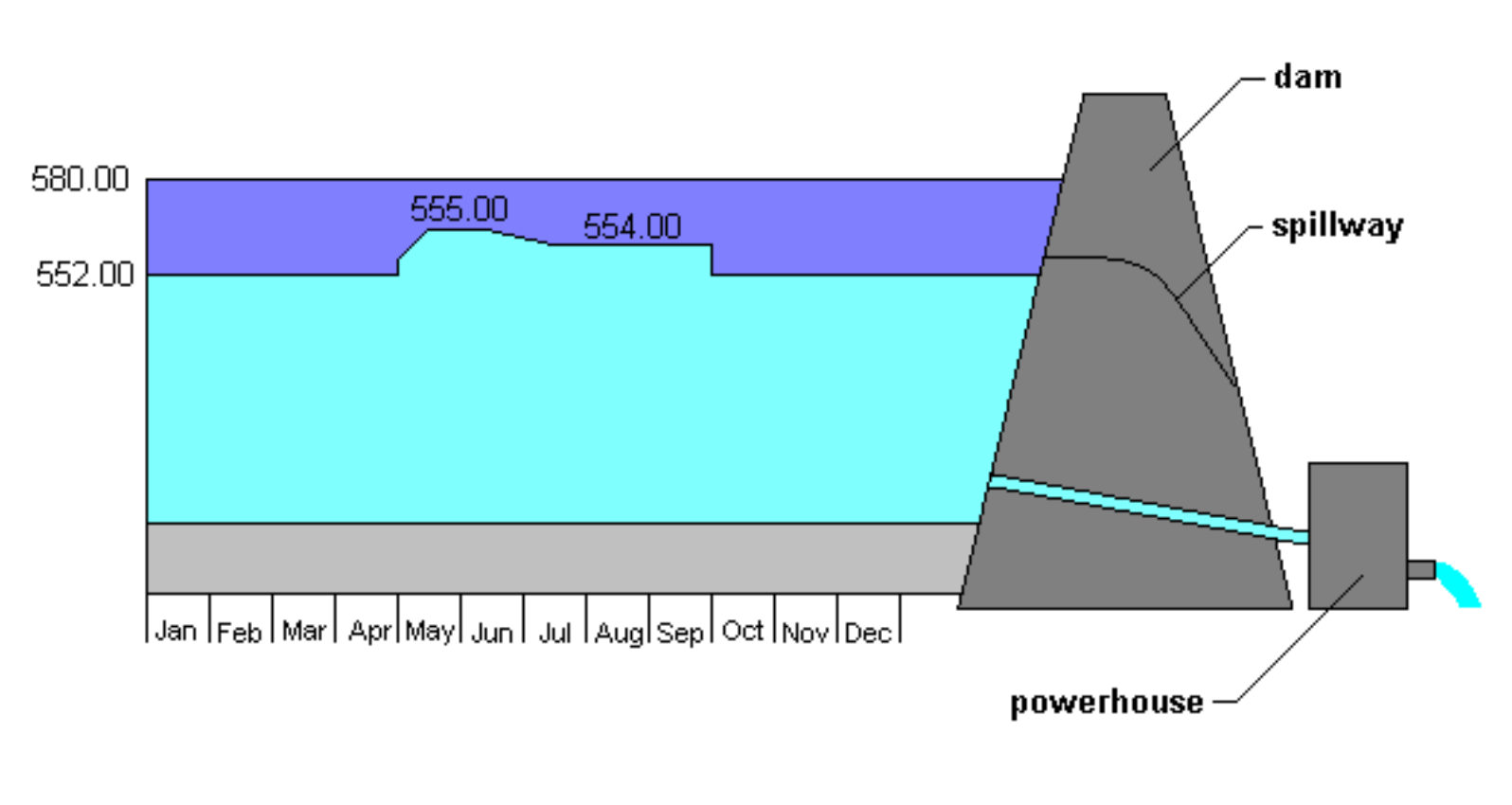
Norfork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dam
spillway
powerhouse

Bull Shoals/Norfork Regulation Criteria

- **Bull Shoals flood releases (from elevation 654.0 to 695.0)**
- **Norfork flood releases (from elevation 552.0 to 580.0)**
  - Maintain seasonal regulating stage at Newport
    - Prorate releases between Bull Shoals and Norfork
      - Maintain a balance in percent flood control storage remaining between the Bull Shoals-Table Rock-Beaver System and Norfork
      - System balancing provides the most flood storage available

Bull Shoals/Norfork Regulation Criteria

(continued)

- **Bull Shoals and Norfork at any elevation in the flood pool AND Newport above seasonal regulating stage**
  - In extreme cases curtail releases to zero if significant reduction in critical downstream flooding is possible
  - Curtail releases to firm power
    - Bull Shoals - 3,750 dsf; 1,352 mwh
    - Norfork - 1,300 dsf; 410 mwh
  - Curtail secondary power releases until 6 days after the flood crest at Newport
    - Secondary releases should maintain receding stages at Newport until seasonal regulating stage is achieved

Bull Shoals/Norfork Regulation Criteria

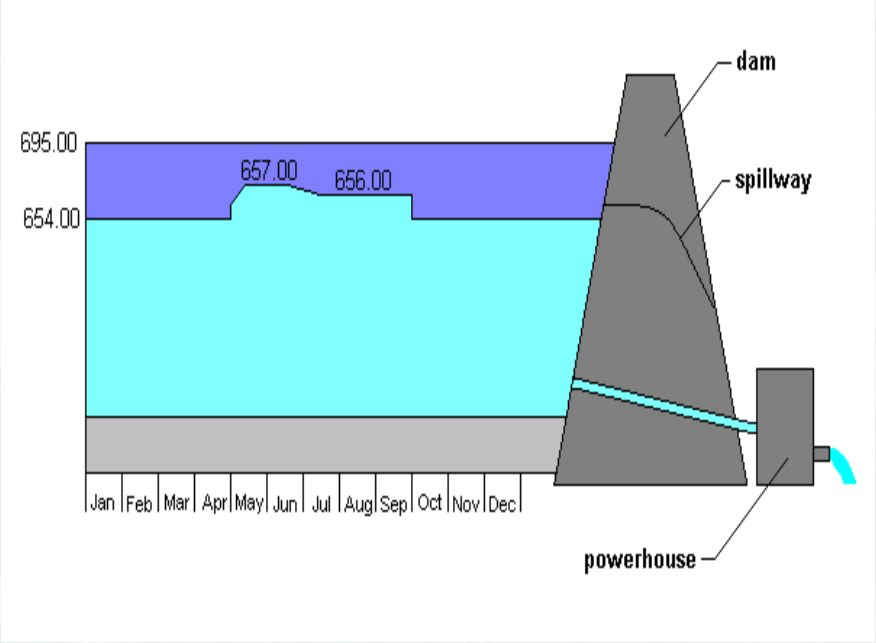
(continued)

- **Bull Shoals above elevation 695.0 or predicted to exceed 695.0 OR**
- **Norfork above elevation 580.0 or predicted to exceed 580.0**
  - Regulate to obtain most effective flood modification with designated surcharge storage space

Bull Shoals vs. Table Rock Regulation

- System regulation approach
  - Long term hydrologic perspective
  - Better insure full use of the total combined flood storage
  - Objective is to reduce peak flood flows
- BV, TR, BS, & NF as a 4-lake sub-system
  - Release of stored flood waters determined by Newport
  - Lake level balance scheme
    - To optimize the use of flood storage
    - Percent flood storage in use at BV-TR-BS about equals flood storage in use at NF
    - Does not attempt to balance flood storage “depth” or individual lake percent flood storage in use
  - This approach manages the flood risk at all lakes

Bull Shoals/Table Rock Comparison



Bull Shoals purpose is to reduce flood peaks in the lower White River valley

- Flood pool varies **41 ft**
- Largest flood storage capacity
- When Bull Shoals is:
  - 5 ft high it has 10% flood storage
  - 10 ft high it has 20% flood storage
  - 15 ft high it has 31% flood storage

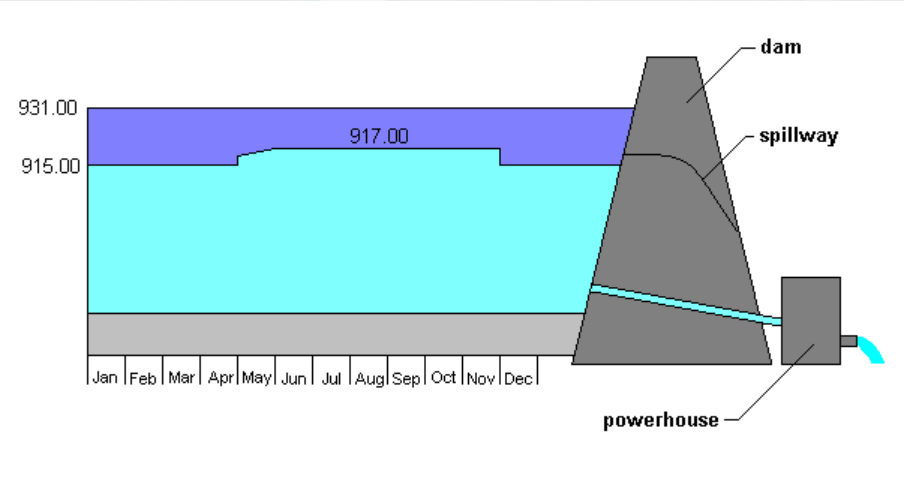
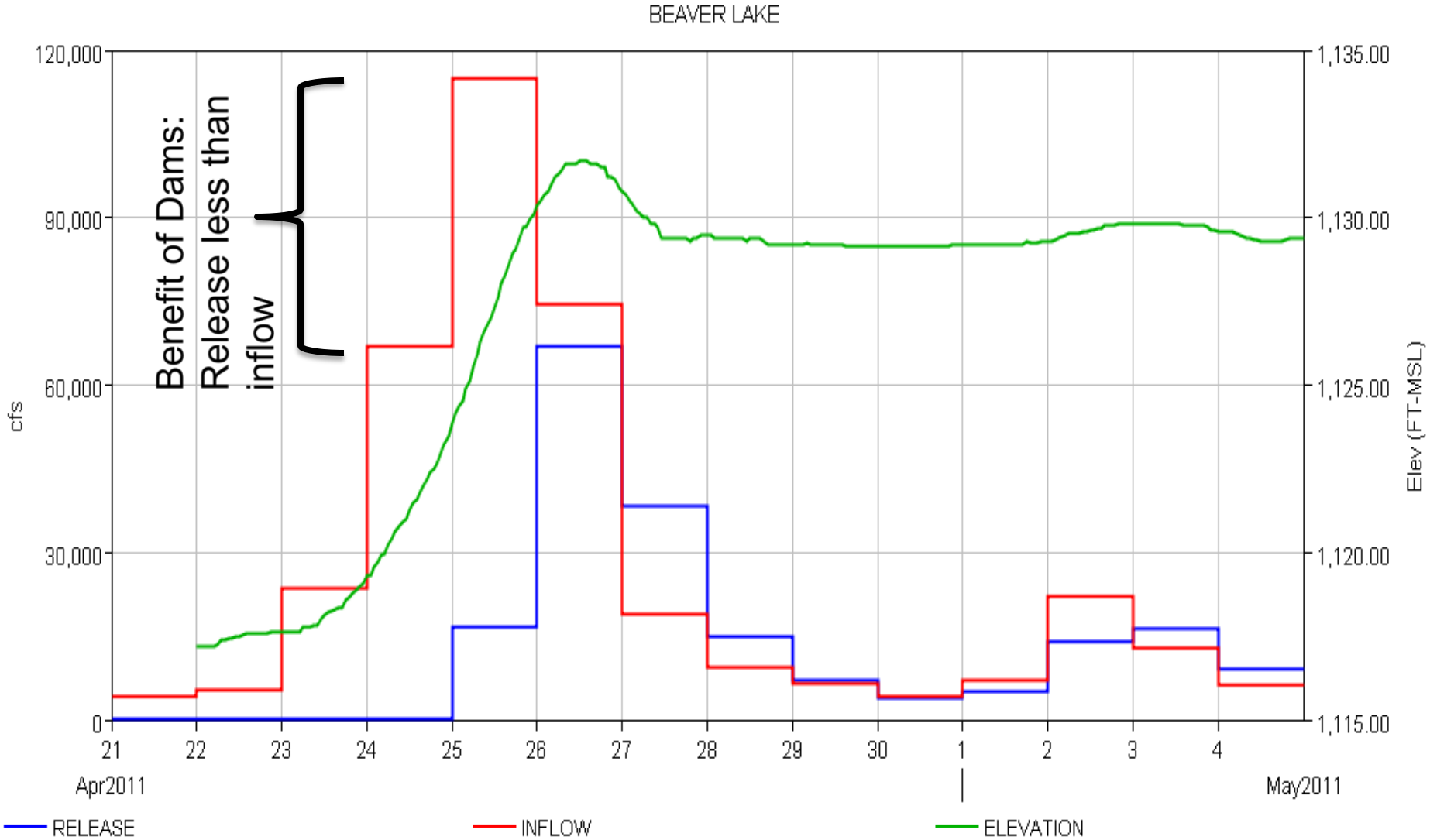


Table Rock's purpose is to reduce flood peaks in the immediate downstream reach to BS and the lower White River

- Flood pool fluctuates **16 ft**
- When Table Rock is:
  - 5 ft high it has 35% flood storage
  - 10 ft high it has 67% flood storage
  - 15 ft high it has 99% flood storage

Plots of Observed vs. Estimated Natural Conditions



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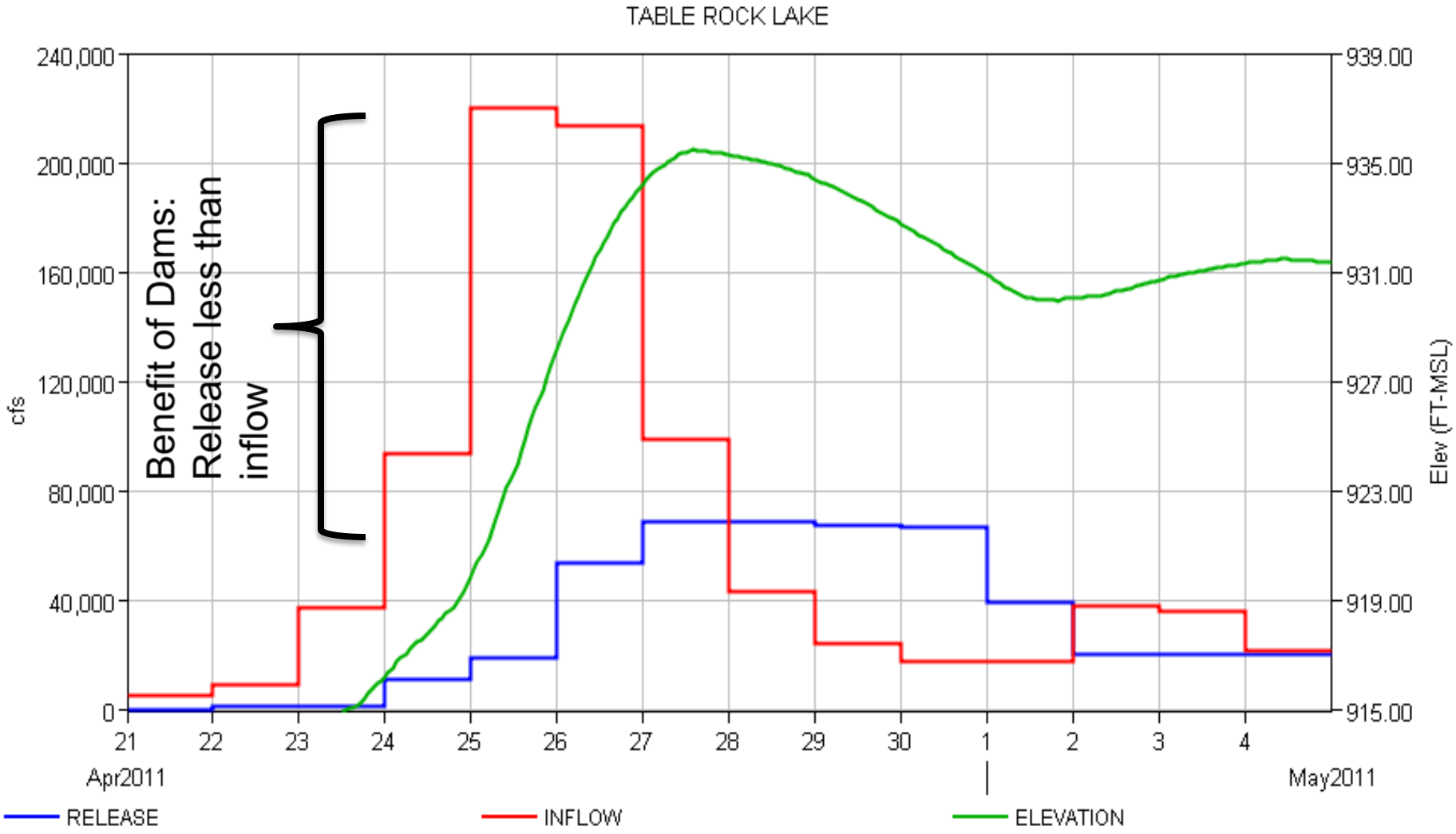
TABLE ROCK LAKE
240,000
200,000
160,000
120,000
80,000
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cfs
939.00
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931.00
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Elev (FT-MSL)
Benefit of Dams:
Release less than
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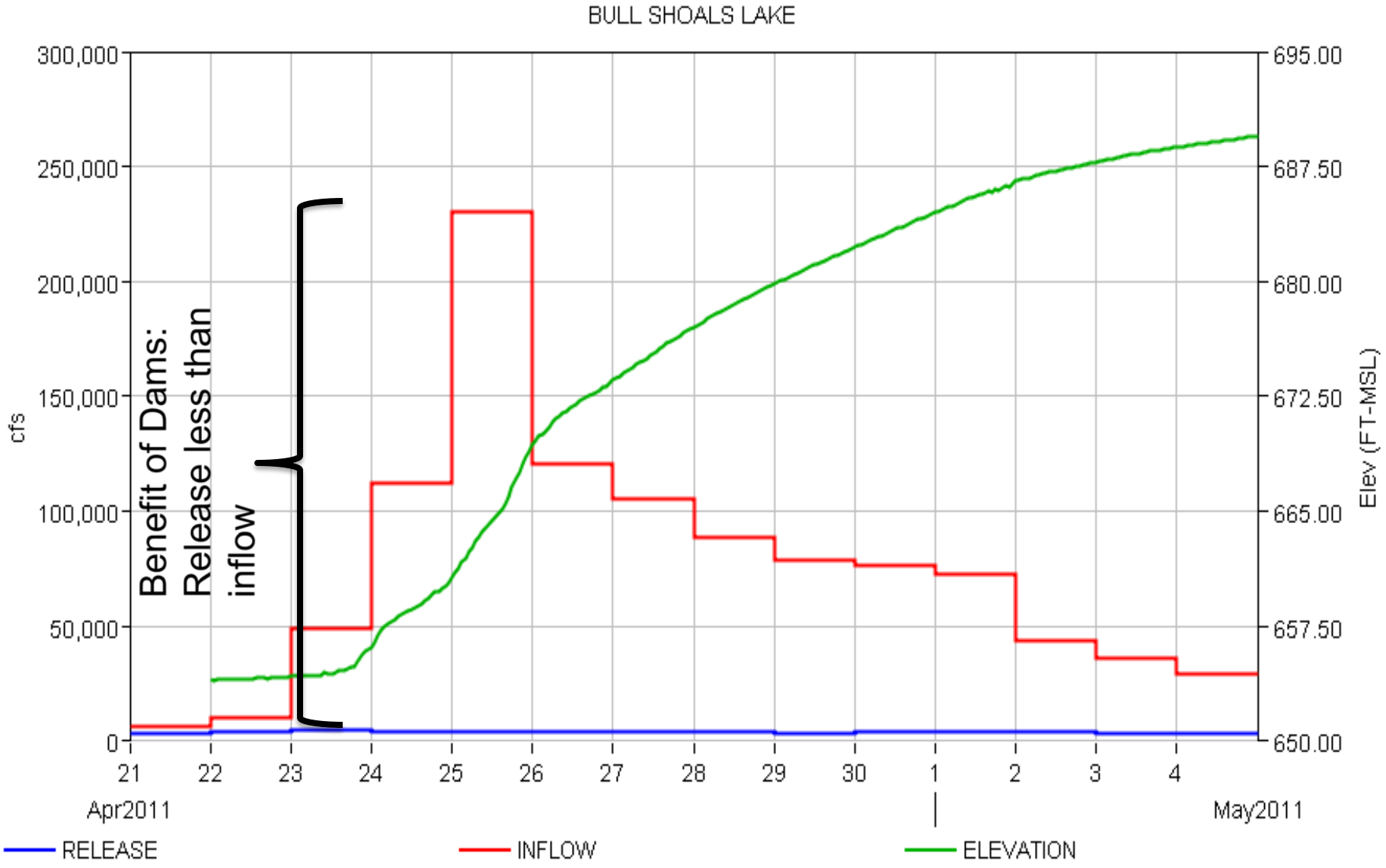
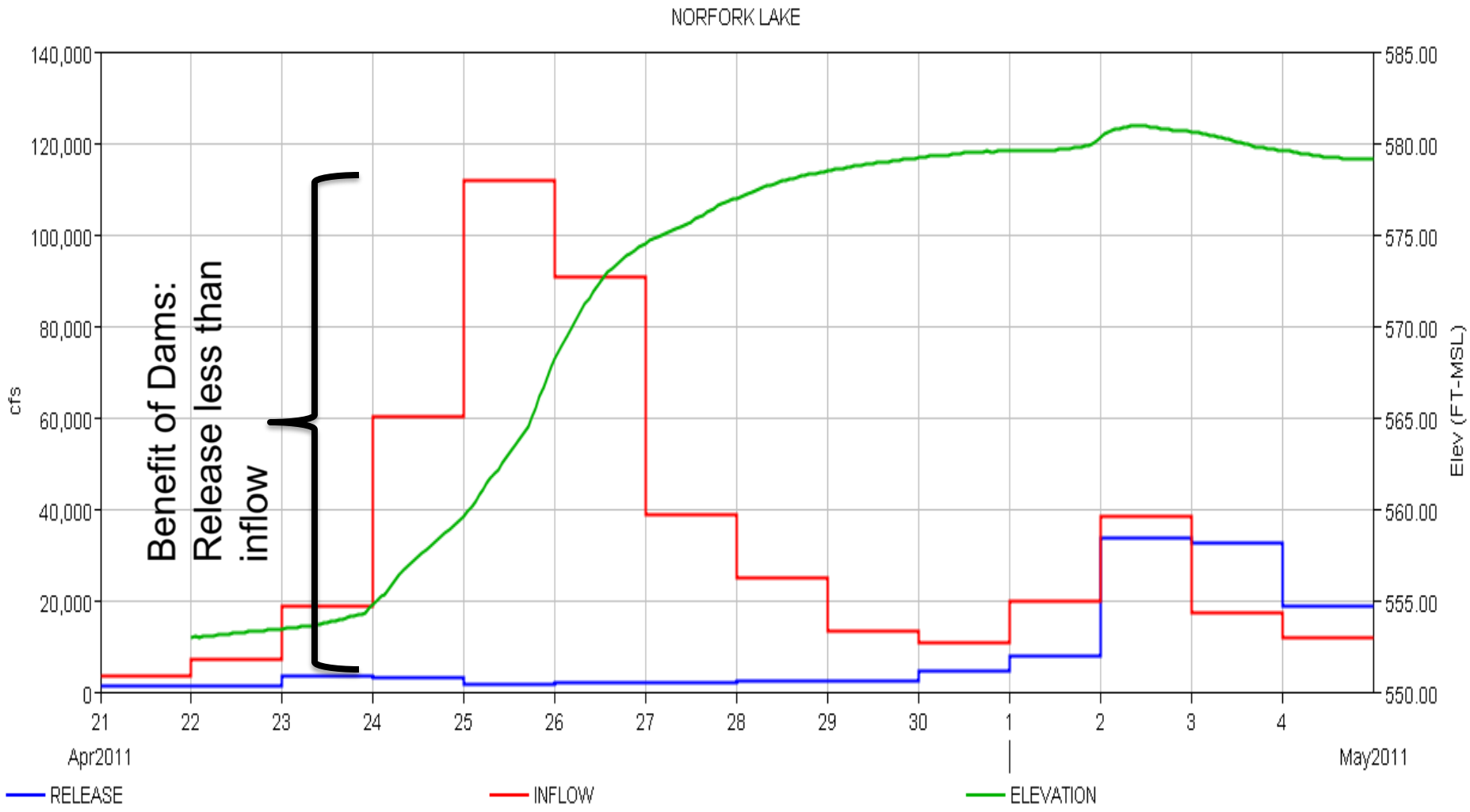
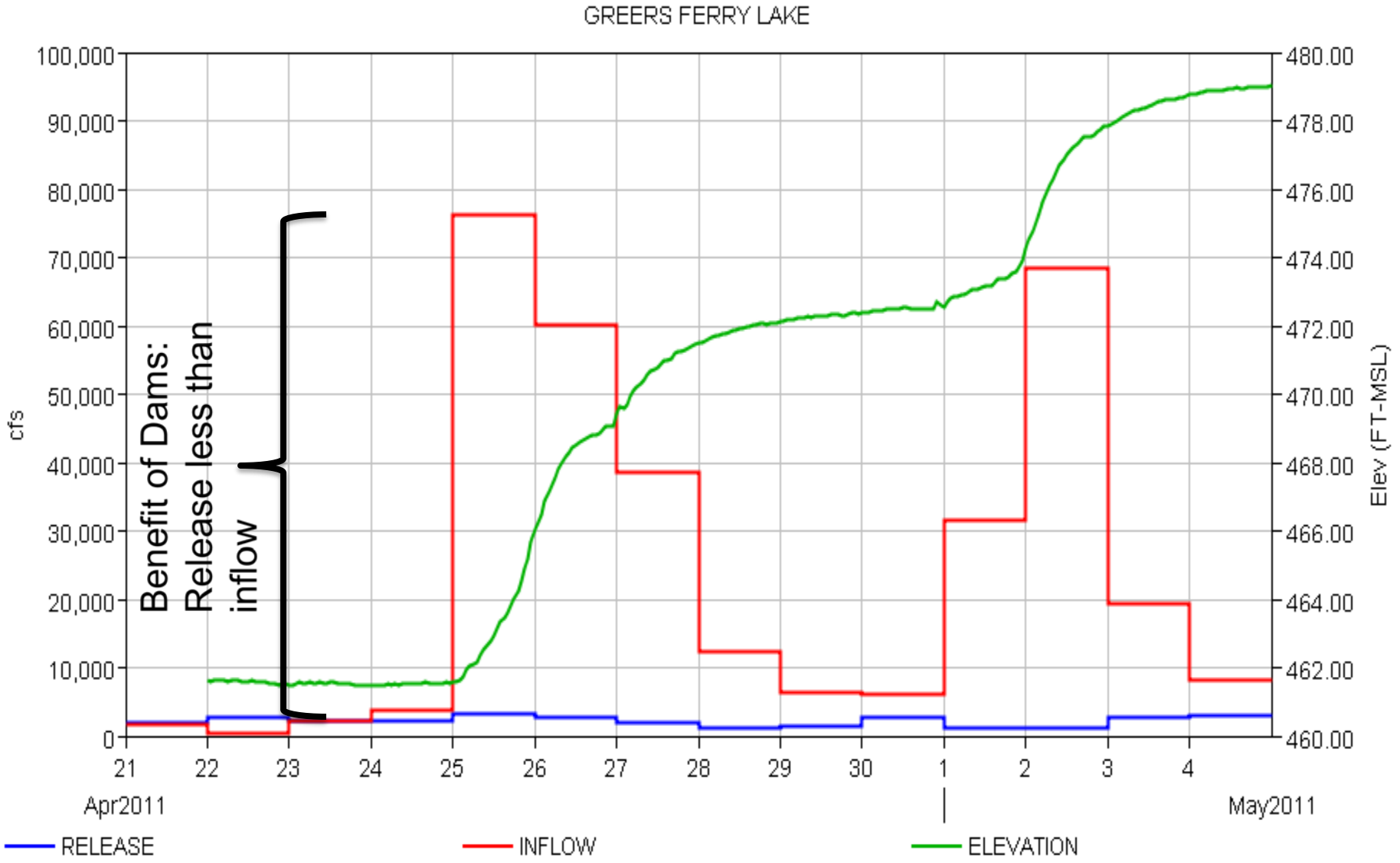
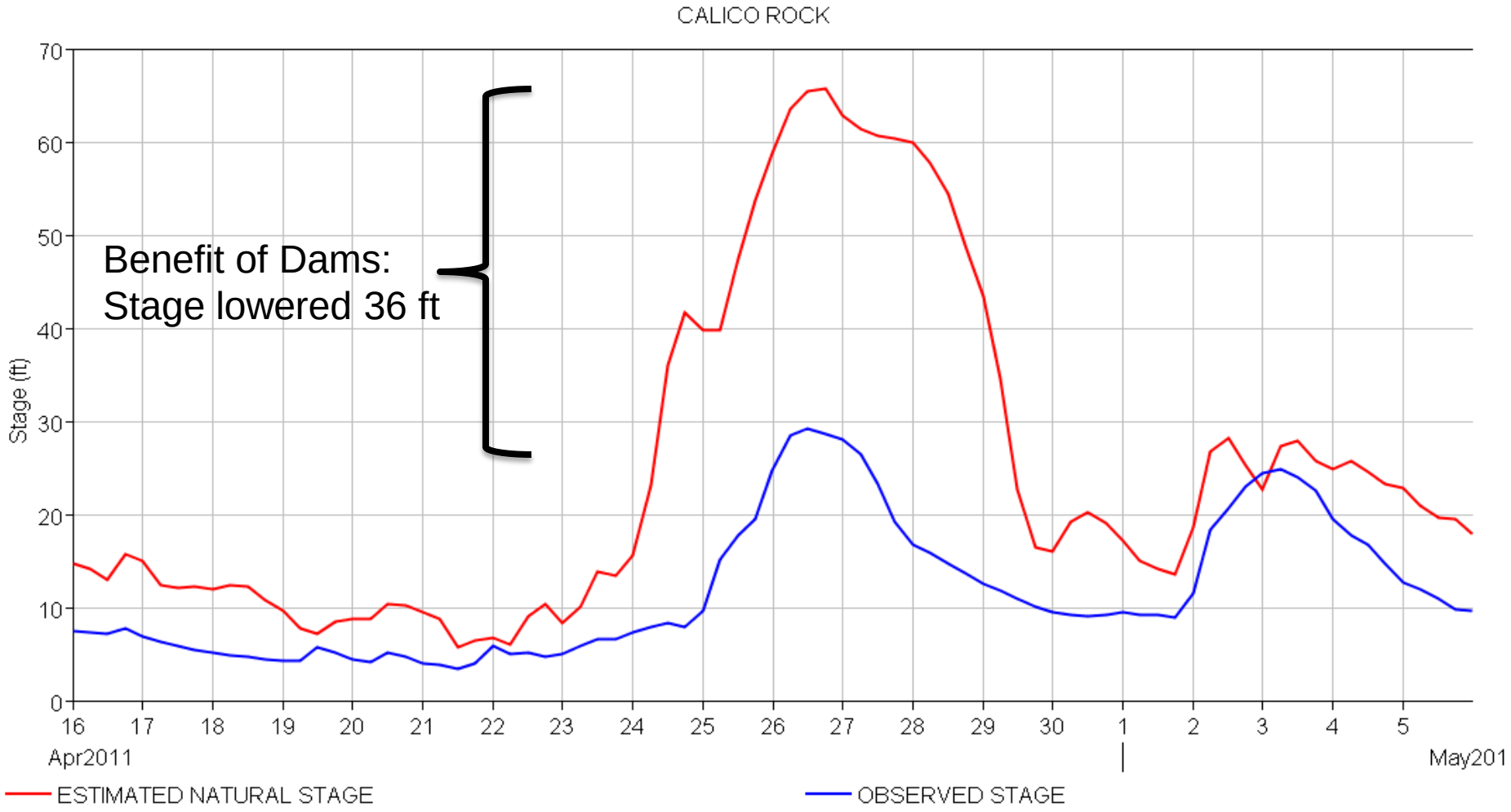
30
1
2
3
4
Apr2011
May2011
RELEASE
INFLOW
ELEVATION

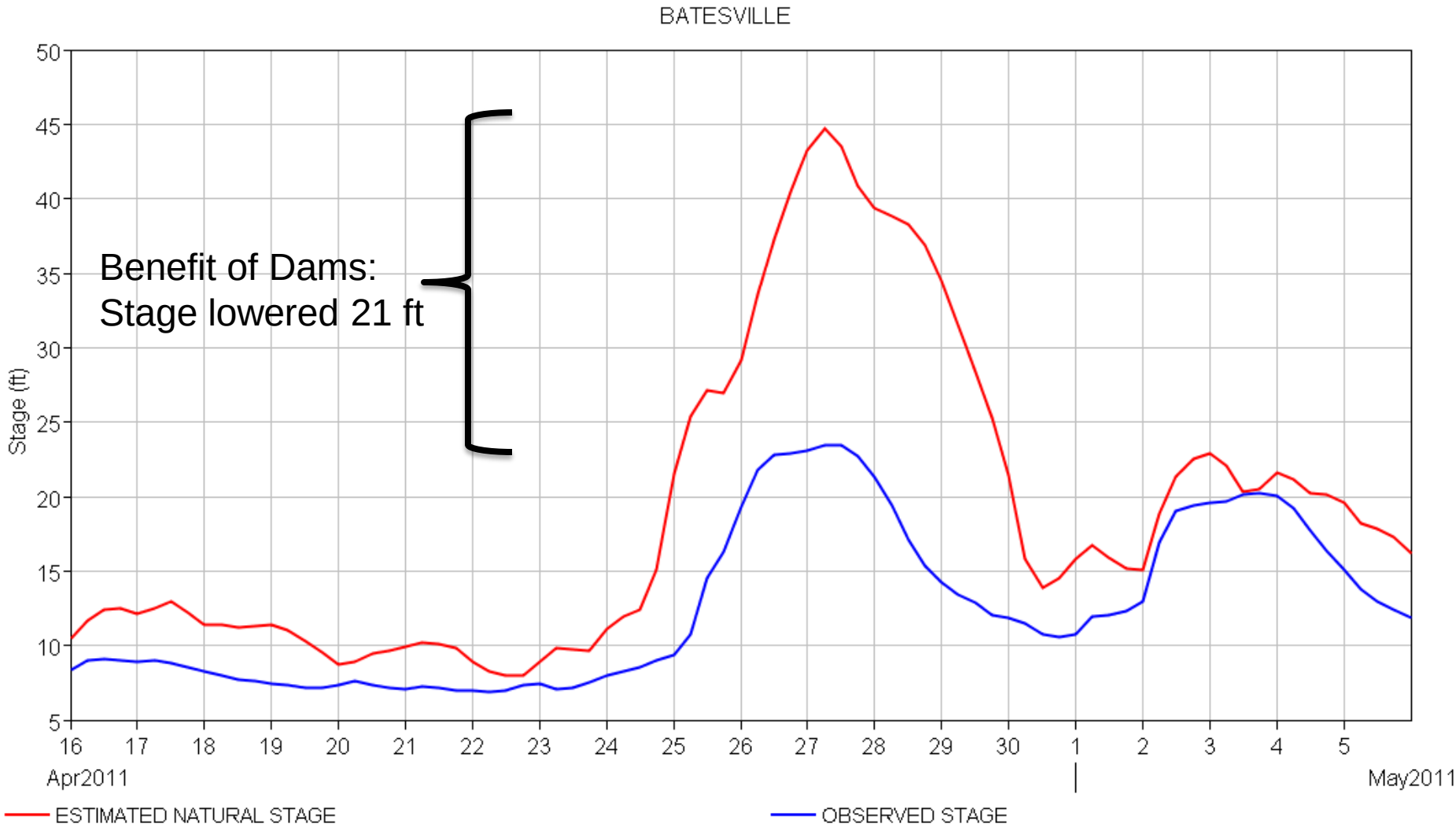

BULL SHOALS LAKE
300,000
250,000
200,000
150,000
100,000
50,000
0
cfs
695.00
687.50
680.00
672.50
665.00
657.50
650.00
Elev (FT-MSL)
21
22
23
24
25
26
27
28
29
30
1
2
3
4
Apr2011
May2011
Benefit of Dams:
Release less than
inflow
RELEASE
INFLOW
ELEVATION

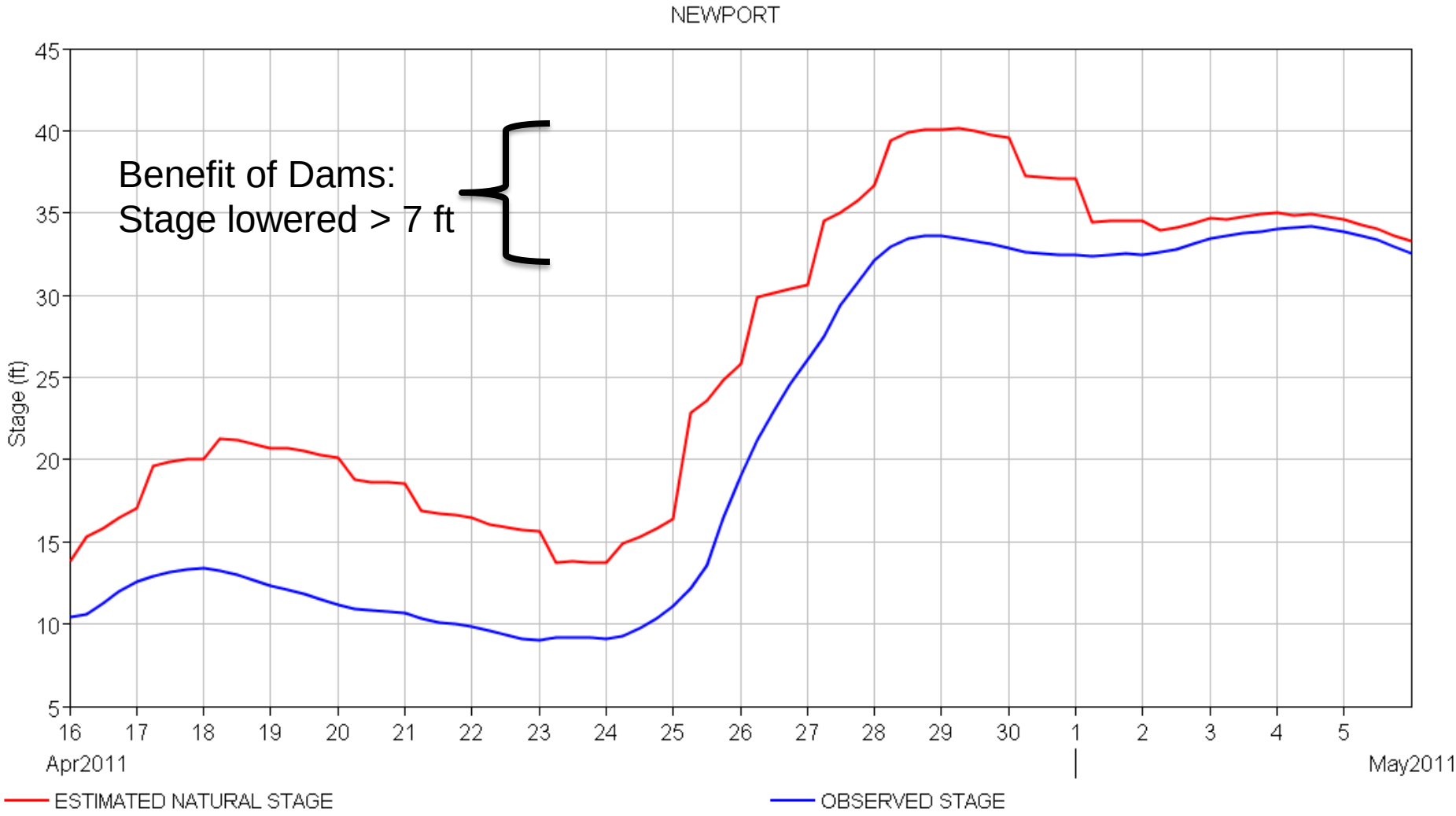

NORFORK LAKE
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
cfs
585.00
580.00
575.00
570.00
565.00
560.00
555.00
550.00
Elev (FT-MSL)
21
22
23
24
25
26
27
28
29
30
1
2
3
4
Apr2011
May2011
Benefit of Dams:
Release less than
inflow
RELEASE
INFLOW
ELEVATION

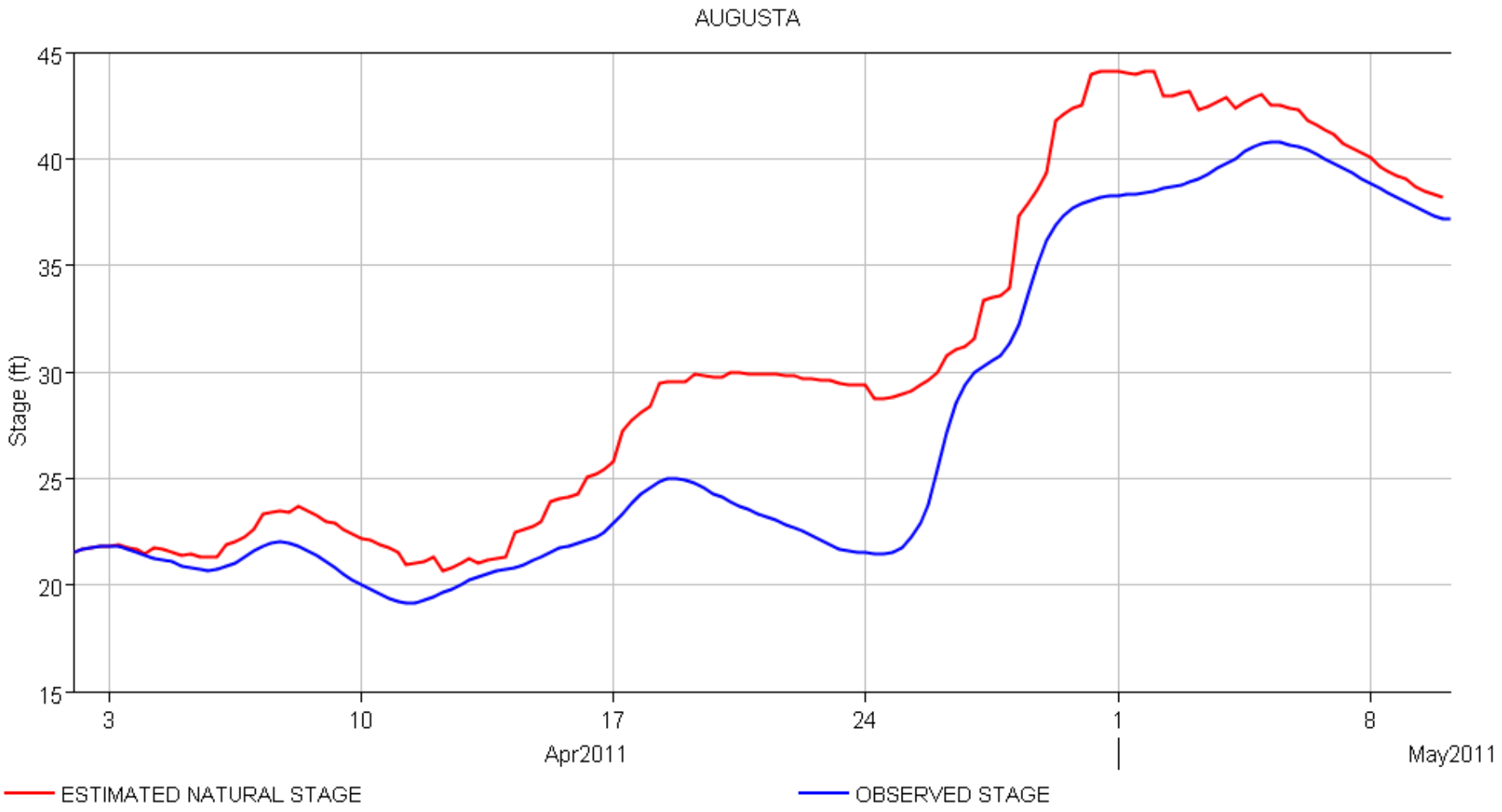

GREERS FERRY LAKE
cfs
Elev (FT-MSL)
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
480.00
478.00
476.00
474.00
472.00
470.00
468.00
466.00
464.00
462.00
460.00
21
22
23
24
25
26
27
28
29
30
1
2
3
4
Apr2011
May2011
Benefit of Dams:
Release less than
inflow
RELEASE
INFLOW
ELEVATION

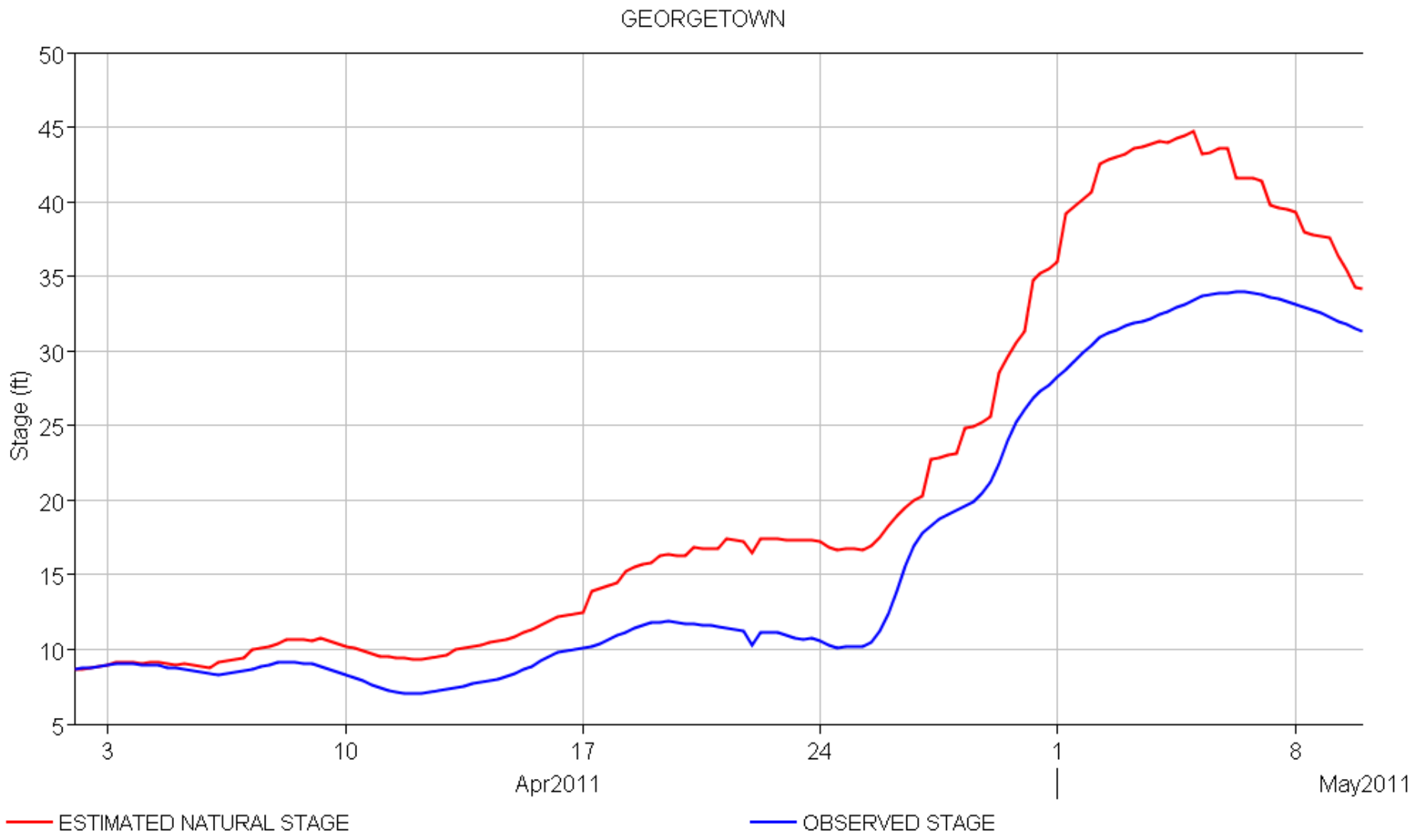


BUILDING STRONG®


BATESVILLE
Stage (ft)
50
45
40
35
30
25
20
15
10
5
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
1
2
3
4
5
Apr2011
May2011
Benefit of Dams:
Stage lowered 21 ft
ESTIMATED NATURAL STAGE
OBSERVED STAGE


NEWPORT
Benefit of Dams:
Stage lowered > 7 ft
Stage (ft)
45
40
35
30
25
20
15
10
5
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
1
2
3
4
5
Apr2011
May2011
ESTIMATED NATURAL STAGE
OBSERVED STAGE


AUGUSTA
45
40
35
30
25
20
15
Stage (ft)
3
10
17
24
1
8
Apr2011
May2011
ESTIMATED NATURAL STAGE
OBSERVED STAGE


GEORGETOWN
Stage (ft)
50
45
40
35
30
25
20
15
10
5
3
10
17
24
1
8
Apr2011
May2011
ESTIMATED NATURAL STAGE
OBSERVED STAGE