How to Compare Alternatives from a Water Supply Viewpoint

July 16, 2013

Ecological Flow Science Advisory Board

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Presentation Outline

- Procedure to compare alternatives from a water users viewpoint.
- How is DWR going to use an EFSAB recommendation.

How much water needs to remain in the river to protect ecological integrity and still have adequate water available for reasonable use?

- **The water users prospective is not part of the EFSAB's charge.**
- **The water users prospective is part of DWR's implementation.**
  - **What is a reasonable approach to compare alternatives from a water users viewpoint?**
- **We looked at 3 alternative approaches. If requested by the EFSAB we will add other alternatives.**

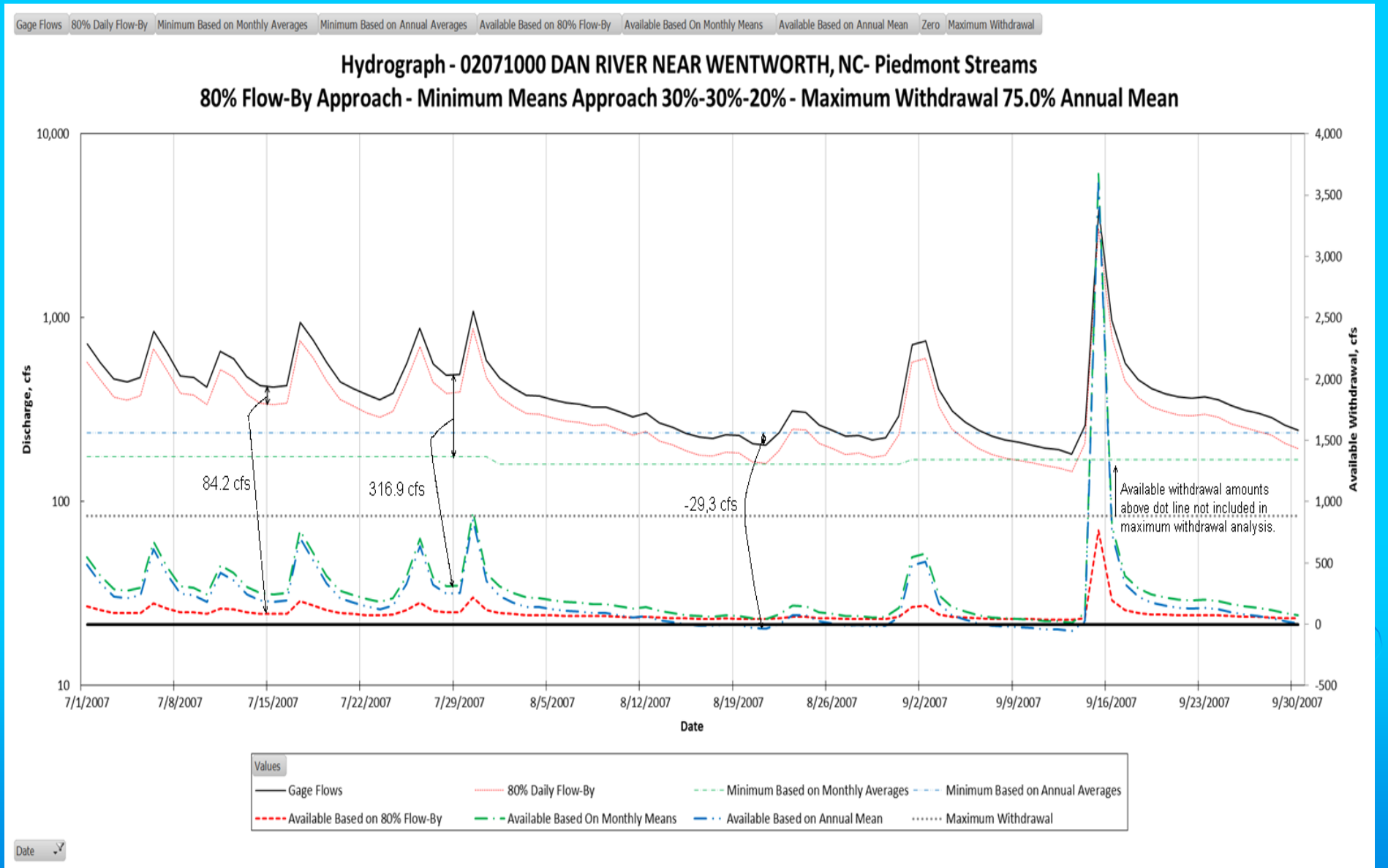
3 Alternative Approaches

1. **Maximum withdrawal – SEPA minimum criteria, 20% 7Q10.**
2. **Flow-By – DWR's 80% Flow-By**
3. **Minimum Flow – Modified South Carolina minimum flows.**

Analysis Approach

- **For the different alternatives determine:**
  1. **Worse Case average daily demand (ADD)**
     - **Analysis assumed a run-of-river intake based on the lowest flow for the period-of-record (POR). Assumed a 1.35 peaking factor and 32.5% mandatory drought conservation.**
  2. **Maximum Pumping**
     - **Maximum pumping volume with a maximum pumping limit of 75% of the mean annual flow.**

Example Hydrograph



ADD Summary

		SEPA Minimum Criteria 20% 7Q10	80% Flow-By Approach Maximum withdrawal set at 20% POR Minimum	80% Flow-By Approach Maximum withdrawal set at 10th Percentile
Gage Name	**Physiographic Region**	**ADD mgd**	**ADD mgd**	**ADD mgd**
Roaring River near Roaring River	Mountain Streams	5.14	1.84	9.93
Linville River at Nebo	**Mountain Streams**	**2.40**	**1.13**	**5.39**
South Fork New River at Jefferson	Mountain Streams	14.54	9.22	23.69
Mills River at Mills River	Mountain Streams	4.04	2.55	7.66
French Broad River at Marshall	Mountain Streams	66.55	27.66	122.99
East Fork Pigeon River near Canton	Mountain Streams	2.46	1.56	4.96
Little Tennessee River at Needmore	Mountain Streams	10.16	5.25	17.73
Dan River near Wentworth	Piedmont Streams	24.24	8.94	55.46
Tar River at US401 at Louisburg	Piedmont Streams	0.95	0.30	4.68
Deep River at Ramseur	**Piedmont Streams**	**1.81**	**0.10**	**5.25**
Cape Fear River at Lillington - POR	Piedmont Streams	14.66	1.56	57.03
Cape Fear River at Lillington - Pre-Impoundment	Piedmont Streams	10.67	1.56	44.83
Cape Fear River at Lillington - Post-Impoundment	Piedmont Streams	48.67	21.99	80.29
Mitchell River near State Road	Piedmont Streams	4.04	1.99	7.52
Fisher River at Copeland	Piedmont Streams	4.07	1.56	9.22
Ararat River at Ararat	Piedmont Streams	7.03	1.84	17.02
Yadkin River at Yadkin College	Piedmont Streams	82.69	33.48	163.13
Rocky River near Norwood	Piedmont Streams	6.63	2.70	14.89
First Broad River near Casar	Piedmont Streams	2.07	0.55	3.97
Tar River at Tarboro	Upper Coastal Plain Streams	12.14	3.97	36.19
Neuse River at Goldsboro	**Upper Coastal Plain Streams**	**20.43**	**11.06**	**53.34**
Contentnea Creek at Hookerton	Upper Coastal Plain Streams	4.05	1.99	12.06
Black River near Tomahawk	Upper Coastal Plain Streams	3.26	0.99	14.19
Northeast Cape Fear River near Chinquapin	Upper Coastal Plain Streams	1.62	0.61	7.94
Lumber River at Boardman	Upper Coastal Plain Streams	15.70	5.96	39.58

Average	14.80	6.01	32.76
Percent Difference Based on 20% 7Q10		-59.36%	121.32%
Minimum	0.95	0.10	3.97
Maximum	82.69	33.48	163.13

Modified SC Summary

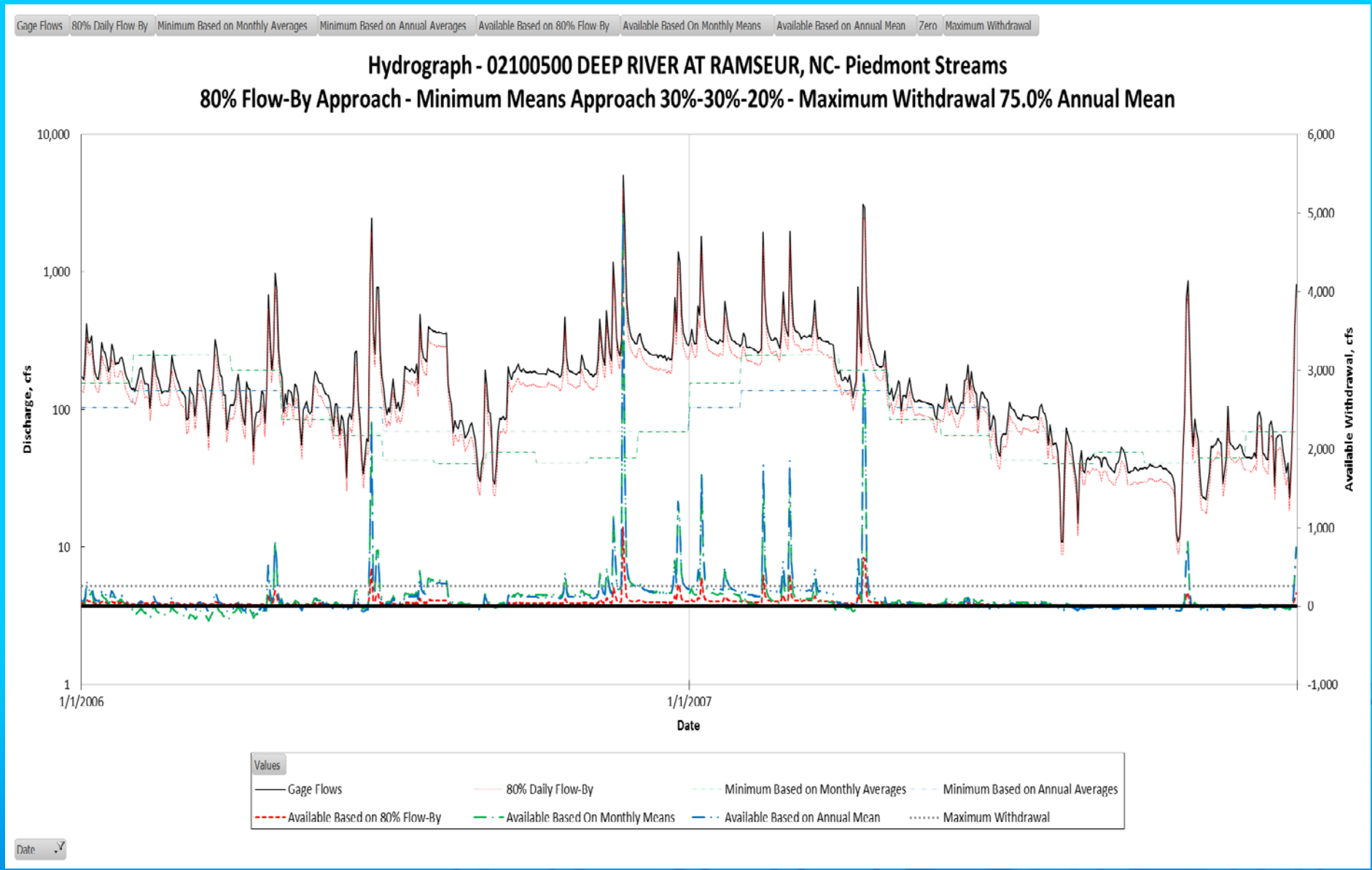
Gage Name	Physiographic Region	Based on Annual Mean Approach Modified SC Minimums		Based on Monthly Means Approach Modified SC Minimums	
		Days Below Minimum, Percent	Number of Periods, Periods/Year	Days Below Minimum, Percent	Number of Periods, Periods/Year
Roaring River near Roaring River	Mountain Streams	3.5%	1.61	3.9%	1.95
Linville River at Nebo	**Mountain Streams**	**11.4%**	**5.40**	**10.6%**	**5.36**
South Fork New River at Jefferson	Mountain Streams	2.7%	1.71	2.4%	1.84
Mills River at Mills River	Mountain Streams	6.8%	2.79	5.6%	2.92
French Broad River at Marshall	Mountain Streams	4.2%	1.77	3.5%	1.57
East Fork Pigeon River near Canton	Mountain Streams	10.6%	4.91	9.3%	4.10
Little Tennessee River at Needmore	Mountain Streams	4.7%	2.27	3.4%	1.78
Dan River near Wentworth	Piedmont Streams	2.6%	1.59	3.4%	2.55
Tar River at US401 at Louisburg	Piedmont Streams	37.3%	11.31	32.4%	13.11
Deep River at Ramseur	**Piedmont Streams**	**31.3%**	**21.99**	**26.9%**	**22.24**
Cape Fear River at Lillington - POR	Piedmont Streams	31.6%	15.35	24.2%	14.23
Cape Fear River at Lillington - Pre-Impoundment	Piedmont Streams	31.3%	16.48	27.5%	18.19
Cape Fear River at Lillington - Post-Impoundment	Piedmont Streams	27.7%	14.36	18.7%	9.55
Mitchell River near State Road	Piedmont Streams	1.1%	0.75	1.7%	1.12
Fisher River at Copeland	Piedmont Streams	2.2%	1.33	2.6%	1.82
Ararat River at Ararat	Piedmont Streams	1.7%	1.44	2.3%	1.85
Yadkin River at Yadkin College	Piedmont Streams	1.3%	0.80	1.9%	1.28
Rocky River near Norwood	Piedmont Streams	47.1%	16.85	41.4%	18.09
First Broad River near Casar	Piedmont Streams	4.3%	1.97	5.2%	2.61
Tar River at Tarboro	Upper Coastal Plain Streams	38.0%	8.50	34.0%	10.00
Neuse River at Goldsboro	**Upper Coastal Plain Streams**	**35.3%**	**9.23**	**30.5%**	**10.35**
Contentnea Creek at Hookerton	Upper Coastal Plain Streams	37.6%	8.20	34.6%	9.22
Black River near Tomahawk	Upper Coastal Plain Streams	31.4%	8.50	28.9%	9.28
Northeast Cape Fear River near Chinquapin	Upper Coastal Plain Streams	39.5%	8.25	38.9%	9.51
Lumber River at Boardman	Upper Coastal Plain Streams	22.6%	4.29	17.9%	4.03

Average	18.7%	6.87	16.5%	7.14
Percent Difference Based on 20% 7Q10				
Minimum	1.1%	0.75	1.7%	1.12
Maximum	47.1%	21.99	41.4%	22.24

Maximum Pumping

		Maximum Pumping Analysis Pumping maximum limited to 75.0% mean annual flow			
Gage Name	**Physiographic Region**	**SEPA Minimum Criteria 20% 7Q10 ADD, mgd**	**80% Flow-By Approach ADD, mgd**	**Minimum Flows Based on Annual Mean ADD, mgd**	**Minimum Flows Based on Monthly Means ADD, mgd**
Roaring River near Roaring River	Mountain Streams	5.14	22.14	53.05	52.55
Linville River at Nebo	**Mountain Streams**	**2.40**	**17.22**	**36.25**	**35.52**
South Fork New River at Jefferson	Mountain Streams	14.54	53.06	131.01	129.66
Mills River at Mills River	Mountain Streams	4.04	21.03	49.21	48.70
French Broad River at Marshall	Mountain Streams	66.55	306.04	725.32	717.98
East Fork Pigeon River near Canton	Mountain Streams	2.46	16.92	36.14	35.51
Little Tennessee River at Needmore	Mountain Streams	10.16	47.76	112.55	112.12
Dan River near Wentworth	Piedmont Streams	24.24	138.18	329.46	322.04
Tar River at US401 at Louisburg	Piedmont Streams	0.95	43.27	65.61	62.14
Deep River at Ramseur	**Piedmont Streams**	**Min Flow > 20% 7Q10**	**34.26**	**55.44**	**52.48**
Cape Fear River at Lillington - POR	Piedmont Streams	**Min Flow > 20% 7Q10**	361.03	556.07	539.15
Cape Fear River at Lillington - Pre-Impoundment	Piedmont Streams	**Min Flow > 20% 7Q10**	351.53	558.79	539.84
Cape Fear River at Lillington - Post-Impoundment	Piedmont Streams	**48.67**	359.05	533.70	521.04
Mitchell River near State Road	Piedmont Streams	4.04	15.29	40.44	39.91
Fisher River at Copeland	Piedmont Streams	4.07	21.29	53.56	52.56
Ararat River at Ararat	Piedmont Streams	7.03	37.58	95.89	94.37
Yadkin River at Yadkin College	Piedmont Streams	82.69	361.80	906.57	890.19
Rocky River near Norwood	Piedmont Streams	6.63	121.16	148.63	137.18
First Broad River near Casar	Piedmont Streams	2.07	10.13	24.37	23.90
Tar River at Tarboro	Upper Coastal Plain Streams	12.14	259.47	332.06	329.37
Neuse River at Goldsboro	**Upper Coastal Plain Streams**	**20.43**	**299.56**	**407.28**	**406.03**
Contentnea Creek at Hookerton	Upper Coastal Plain Streams	4.05	93.20	125.11	124.89
Black River near Tomahawk	Upper Coastal Plain Streams	3.26	93.91	142.68	143.34
Northeast Cape Fear River near Chinquapin	Upper Coastal Plain Streams	1.62	82.88	105.67	105.31
Lumber River at Boardman	Upper Coastal Plain Streams	15.70	161.33	281.41	282.05

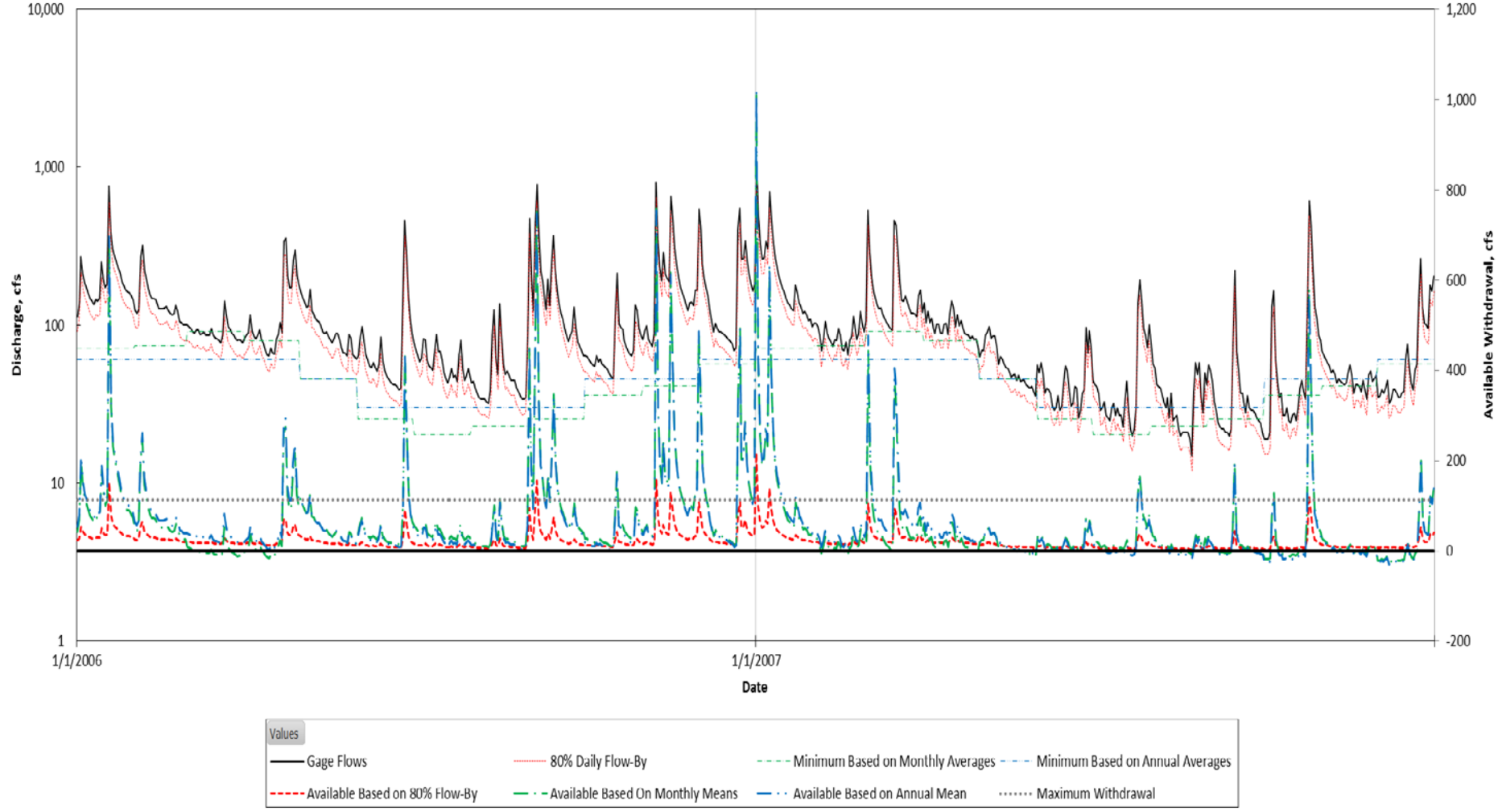
Average	15.59	133.16	236.25	231.91
Percent Difference Based on 20% 7Q10	5.30%	799.71%	1496.20%	1466.90%
Minimum	0.95	10.13	24.37	23.90
Maximum	82.69	361.80	906.57	890.19


Gage Flows
80% Daily Flow By
Minimum Based on Monthly Averages
Minimum Based on Annual Averages
Available Based on 80% Flow By
Available Based On Monthly Means
Available Based on Annual Mean
Zero
Maximum Withdrawal
Hydrograph - 02100500 DEEP RIVER AT RAMSEUR, NC- Piedmont Streams
80% Flow-By Approach - Minimum Means Approach 30%-30%-20% - Maximum Withdrawal 75.0% Annual Mean
Discharge, cfs
Available Withdrawal, cfs
10,000
1,000
100
10
1
6,000
5,000
4,000
3,000
2,000
1,000
0
-1,000
1/1/2006
1/1/2007
Date
Values
Gage Flows
80% Daily Flow-By
Minimum Based on Monthly Averages
Minimum Based on Annual Averages
Available Based on 80% Flow-By
Available Based On Monthly Means
Available Based on Annual Mean
Maximum Withdrawal
Date

Gage Flows | 80% Daily Flow By | Minimum Based on Monthly Averages | Minimum Based on Annual Averages | Available Based on 80% Flow By | Available Based On Monthly Means | Available Based on Annual Mean | Zero | Maximum Withdrawal

Hydrograph - 02138500 LINVILLE RIVER NEAR NEBO, NC- Mountain Streams

80% Flow-By Approach - Minimum Means Approach 40%-30%-20% - Maximum Withdrawal 75.0% Annual Mean



Date

How will DWR implement an EFSAB recommendation?

- **Planning tool**
  - **Will not override existing permits, such as FERC license.**
  - **Will not replace site specific studies.**
  - **Will not change the SEPA minimum criteria – 20% 7Q10**
- **During the planning process if ecologic integrity is determined or projected to be adversely impacted, we will flag the river reach for additional studies.**

Example Using the 80% Flow-By

For illustration purposes only.

- Using the EMC approved river basin model compare the current conditions scenario (SIMBASE) with a future conditions alternative.
- Use permitted flow requirements.
- For nodes with no permit requirements. Create an 80% BASELINE using SIMBASE and compare future conditions scenarios to the baseline. When a scenario flow is below the BASELINE that represents a potential adverse ecological impact.

Example Using the 80% Flow-By

For illustration purposes only.

- **Summarize the analysis for both the full model period-of-record and the IndexB approach of using the data between 10th and 90th percentiles.**
- **Results interpretation**
  - **No Impact (Green) – POR no days with flows < 80%.**
  - **Watch (Yellow) – POR of has 1 or more days < 80% and IndexB has no days < 80%.**
  - **Additional Study (Red) - Both the POR and IndexB have 1 or more days < 80%.**

Broad Model Example

		Broad River Basin - 2060 Scenario Baseline - Simbase (Current Conditions)	
		80% of Flow-By Full Record	80% of Flow-By IndexB Approach (10% - 90%)
Arc Node	Description of the Node	Number of days with potential adverse impacts	Number of days with potential adverse impacts
010.020	Lake Summit Release	0	0
020.040	Green River to Lake Adger	0	0
040.050	Lake Adger Release	168	0
050.060	Green River to Ken Miller	168	0
060.100	Green River to Broad Confluence	168	0
070.080	Lake Lure Release	0	0
080.090	Upper Broad	30	0
090.100	Upper Broad to Broad Confluence	24	0
100.170	Broad River to Foresty City Intake	4	0
150.190	2nd Broad	18	0
190.200	2nd Broad Cliffside	0	0
170.180	Forest City Intake (2nd Broad)	4	0
180.200	Upper Cliffside	4	0
200.220	2nd Broad Confluence	0	0
220.250	Cliffside Dam Release	25	0
250.260	Boiling Spring Gage	4	0
410.415 Cleveland Intake	***Cleveland Intake***	***159***	***0***
415.420	Lawndale Gage	116	0
420.440	Shelby Intake (1st Broad)	131	0
440.450	Stice Shoals Dam Release	0	0
450.500	First Broad Confluence	0	0
500.550	Lower Broad	4	0
550.700	Gaston Shoals Dam Release	104	2
600.610 Kings Mnt Res	***Kings Mountain Reservoir Release***	***290***	***282***
610.650	Kings Mountain WTP Discharge	163	154
650.700	Buffallo Creek Confluence	50	43
700.999	Gaffney Gage	26	0

Number of no impacts nodes	7
Number of watch nodes	16
Number of additional study nodes	4

Questions

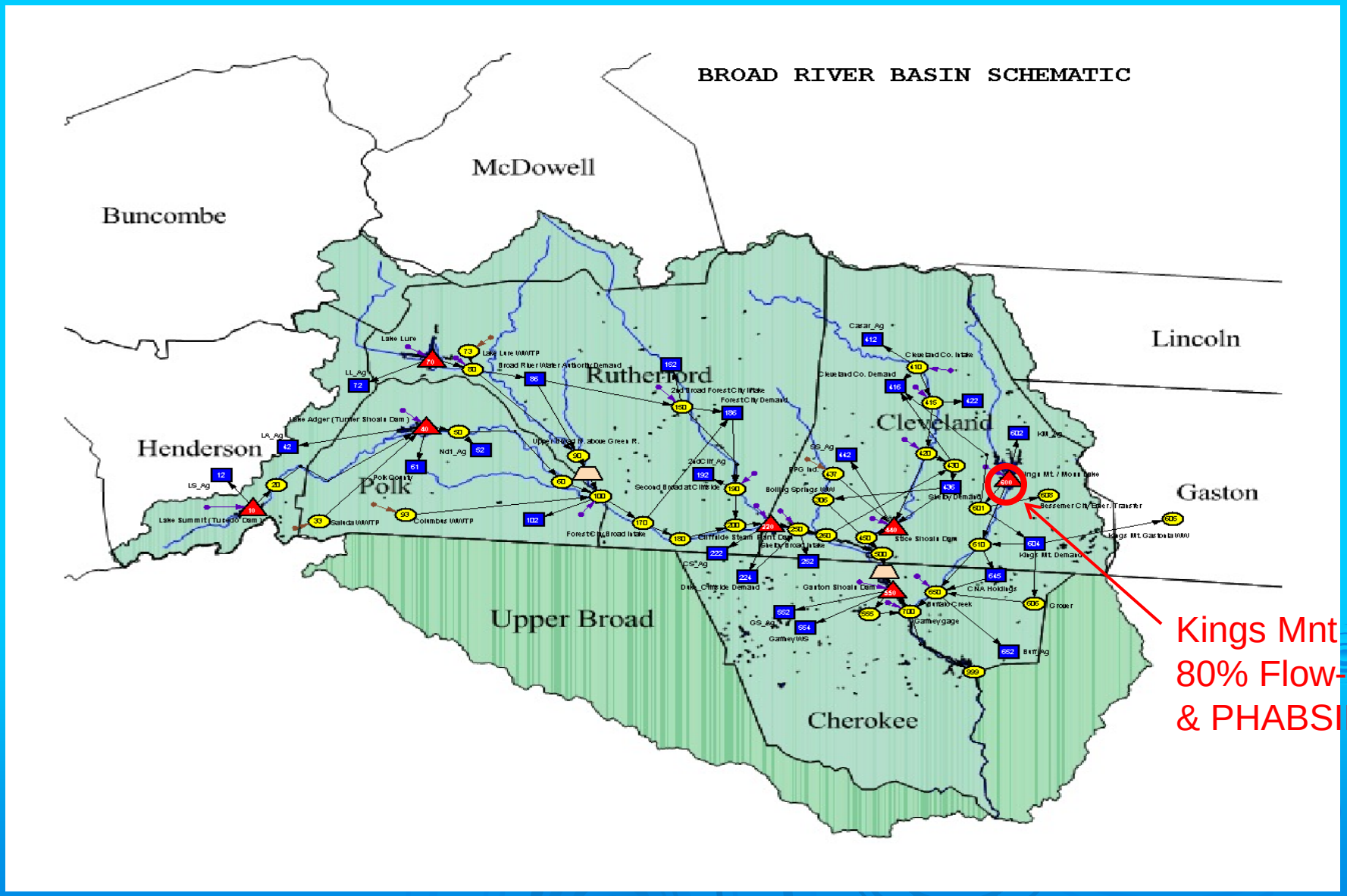
Comparison of Natural vs. Current Conditions (Simbase) PHABSIM & 80% Flow-By

June 18, 2013

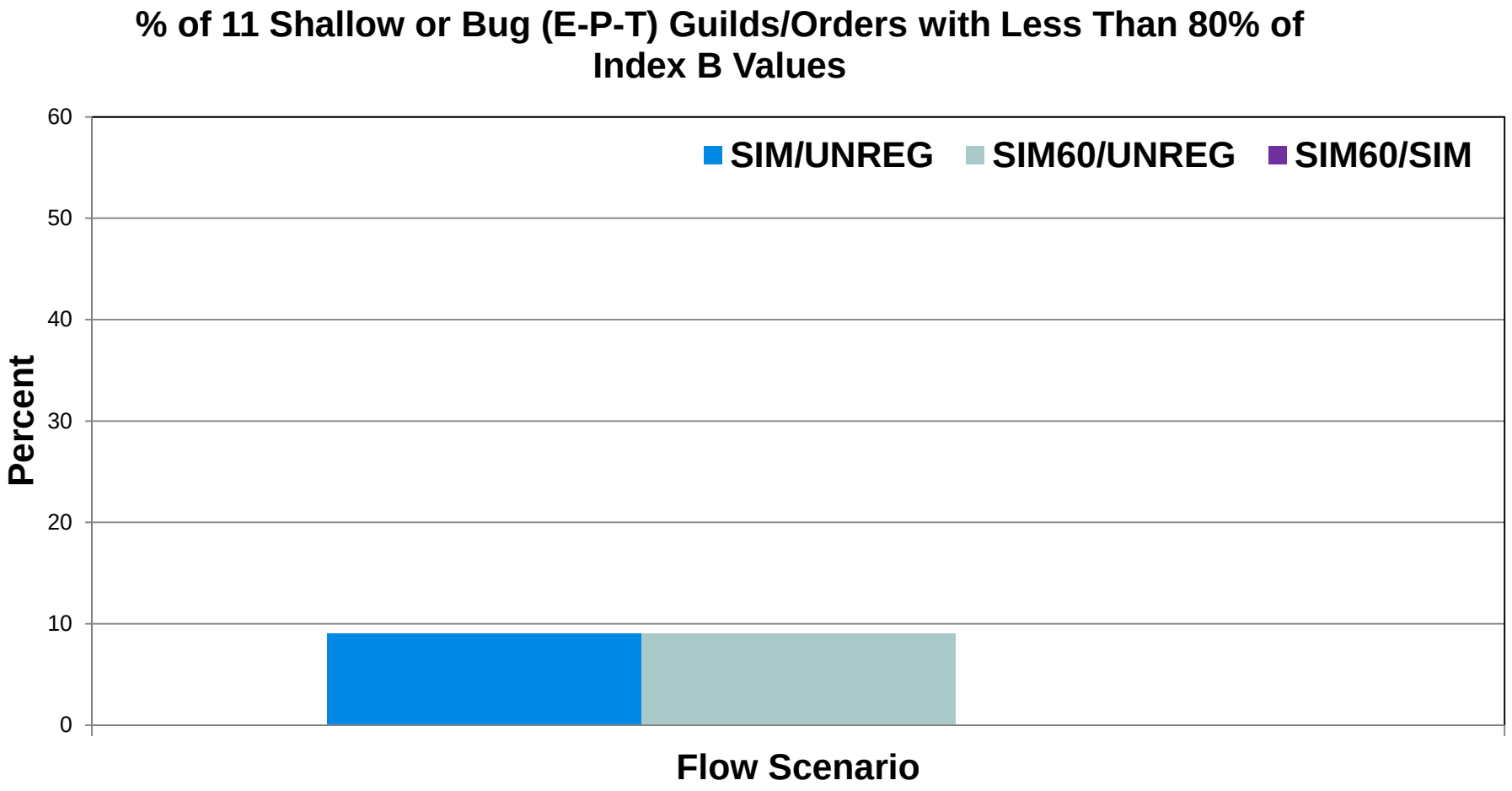
Ecological Flow Science Advisory Board

Fred Tarver & Tom Fransen
Division of Water Resources
NC Department of Environment and Natural Resources

Broad River Basin Model

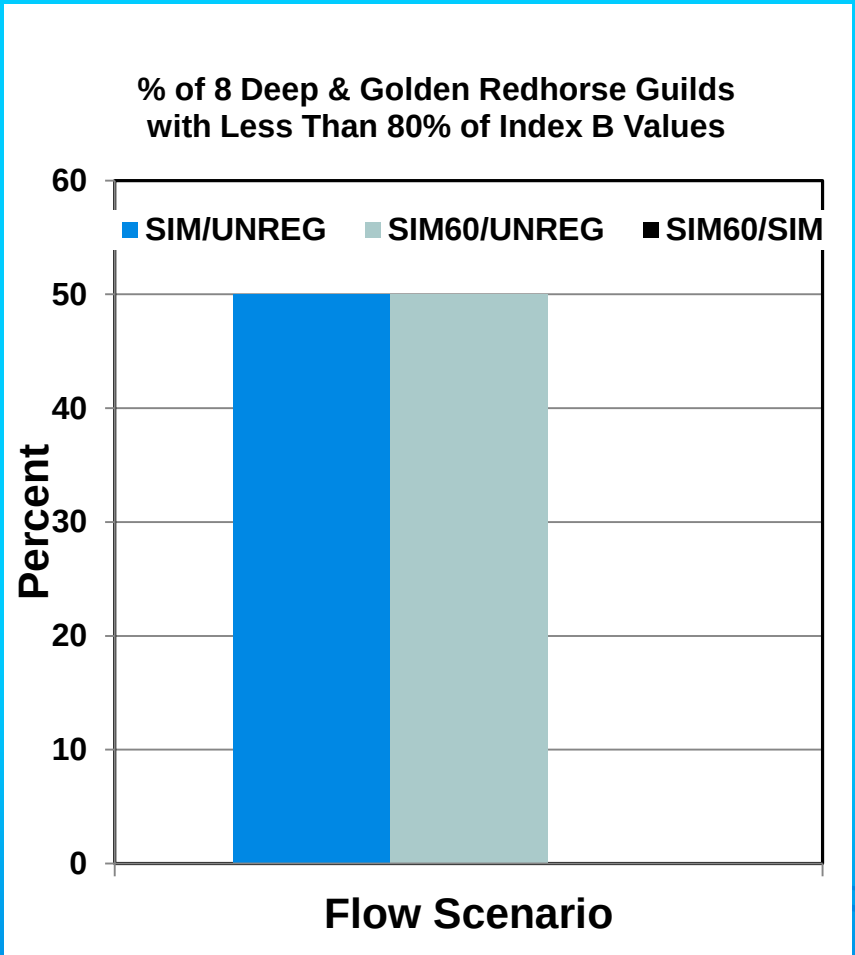


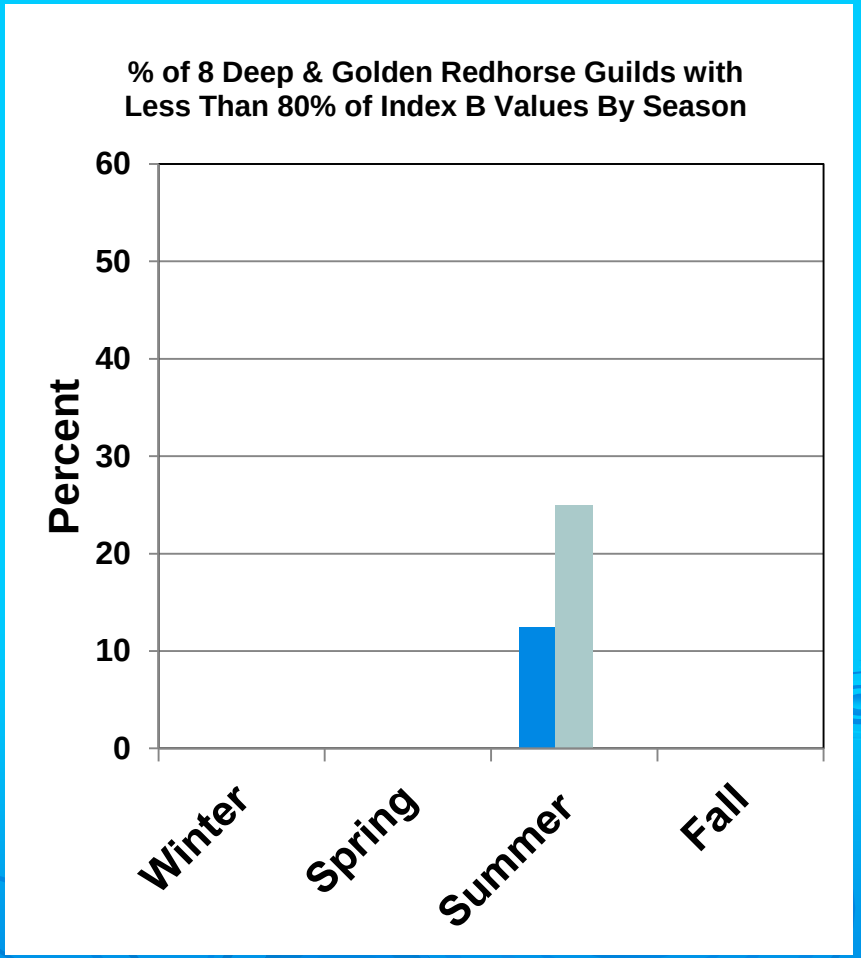
PHABSIM (Shallow)
Arc 600.100 Kings Mnt Reservoir



Seasonal not shown all values are 0.

PHABSIM (Deep)
Arc 600.100 Kings Mnt Reservoir





PHABSIM – Model Scenario Details

- Majority of reductions in habitat are associated with “Deep Fast” guilds where half or nearly half of months fall below 80% threshold.
- “Deep Slow” guilds have 1 or 2 month breaches of 80% threshold.
- Another Deep species (Golden Redhorse Juvenile), with nearly half of months below threshold, had habitat values <500 by month.
- The Simbase and 2060 projection include WWTP return flows, which tend to offset dam alterations.
- Seasonal calculations (Summer) tended to exclude breaches for marginal months when using Index B (mean of habitat events between 10 and 90% exceedence).

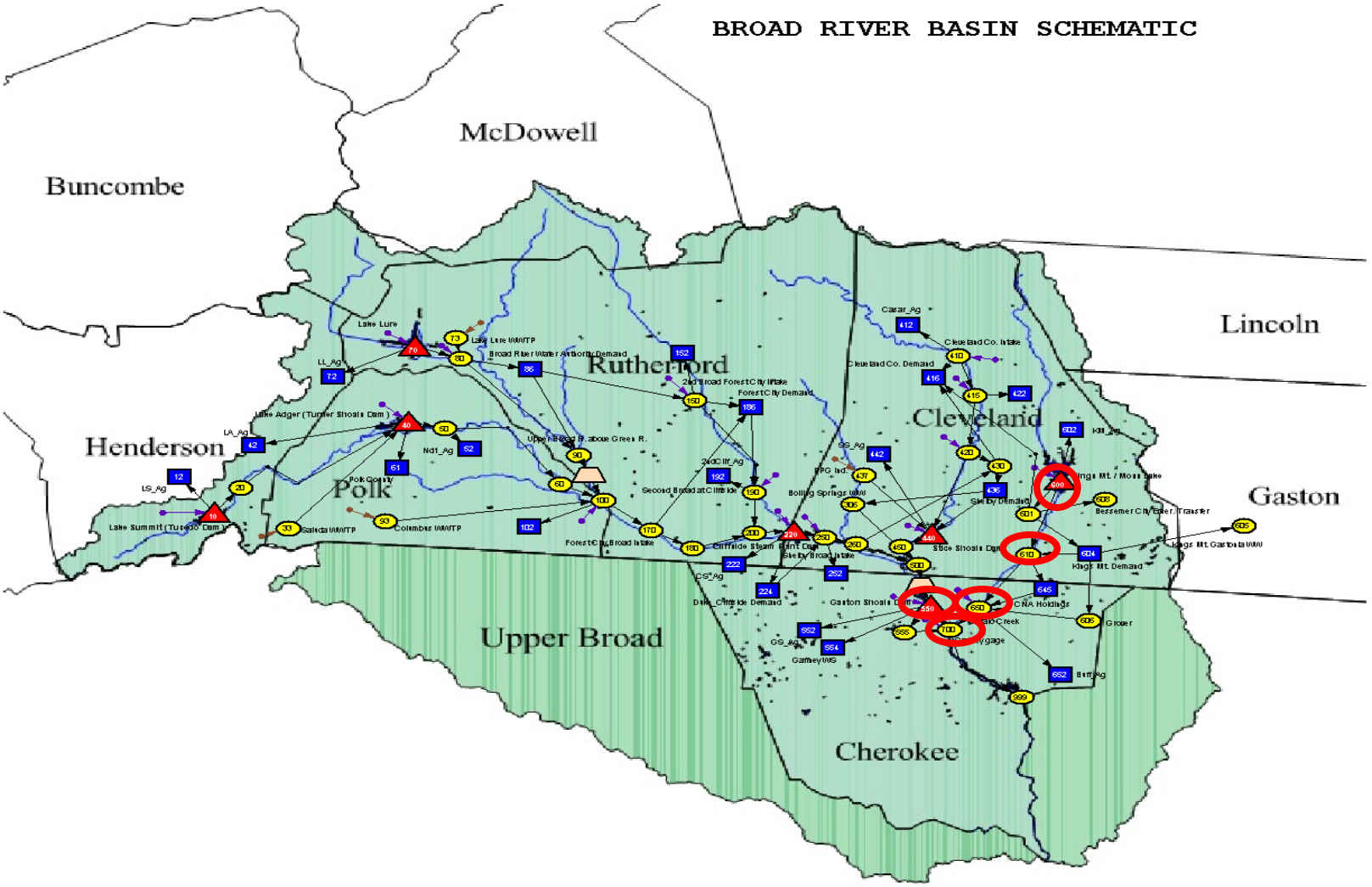
PHABSIM - Comments

- Most of the impacts occurred between Natural and Current Conditions.
- Little to no addition impacts between Current Conditions and projected 2060 scenario conditions.

80% Flow-By Comparison

	Broad River Basin - Simbase (Current Conditions) Scenario Baseline - Natural Flows		Broad River Basin - 2060 Scenario Baseline - Natural Flows		Broad River Basin - 2060 Scenario Baseline - Simbase (Current Conditions)	
	80% of Flow-By IndexB Approach (10% - 90%)		**80% of Flow-By IndexB Approach (10% - 90%)**		**80% of Flow-By IndexB Approach (10% - 90%)**	
Arc Node	**Number of days with potential adverse impacts**	**Percent of days**	**Number of days with potential adverse impacts**	**Percent of days**	**Number of days with potential adverse impacts**	**Percent of days**
010.020	0	0.000%	0	0.000%	0	0.000%
020.040	0	0.000%	0	0.000%	0	0.000%
040.050	0	0.000%	0	0.000%	0	0.000%
050.060	0	0.000%	0	0.000%	0	0.000%
060.100	0	0.000%	0	0.000%	0	0.000%
070.080	0	0.000%	0	0.000%	0	0.000%
080.090	0	0.000%	0	0.000%	0	0.000%
090.100	0	0.000%	0	0.000%	0	0.000%
100.170	0	0.000%	0	0.000%	0	0.000%
150.190	0	0.000%	0	0.000%	0	0.000%
190.200	0	0.000%	0	0.000%	0	0.000%
170.180	0	0.000%	0	0.000%	0	0.000%
180.200	0	0.000%	0	0.000%	0	0.000%
200.220	0	0.000%	0	0.000%	0	0.000%
220.250	0	0.000%	0	0.000%	0	0.000%
250.260	0	0.000%	0	0.000%	0	0.000%
410.415 Cleveland Intake	***0***	***0.000%***	***0***	***0.000%***	***0***	***0.000%***
415.420	0	0.000%	0	0.000%	0	0.000%
420.440	0	0.000%	**0**	**0.000%**	0	0.000%
440.450	0	0.000%	0	0.000%	0	0.000%
450.500	0	0.000%	0	0.000%	0	0.000%
500.550	0	0.000%	0	0.000%	0	0.000%
550.700	35	0.148%	55	0.233%	2	0.008%
600.610 Kings Mnt Res	***8,044***	***34.118%***	***9,763***	***41.409%***	***282***	***1.241%***
610.650	4,807	20.389%	4,845	20.550%	154	0.656%
650.700	178	0.755%	192	0.814%	43	0.182%
700.999	22	0.093%	32	0.136%	0	0.000%

Nodes Potential Impact



Broad River Basin - Simbase (Current Conditions) Scenario
Baseline - Natural Flows
Kings Mountain Reservoir (600.610)
Full Hydrograph

	Natural Flows	80% Natural Flows	Simbase
0.500%	1.97	1.58	12.00
1.000%	4.45	3.56	12.00
2.000%	8.15	6.52	12.00
5.000%	14.67	11.74	12.00
10.000%	21.36	17.09	12.00
15.000%	26.15	20.92	14.79
20.000%	30.16	24.13	20.25
25.000%	34.07	27.26	25.03
30.000%	37.96	30.37	29.26
35.000%	41.30	33.04	33.70
40.000%	45.49	36.40	38.26
45.000%	49.67	39.74	42.85
50.000%	54.57	43.66	48.26
55.000%	59.47	47.58	53.81
60.000%	64.62	51.70	60.19
65.000%	71.17	56.94	67.07
70.000%	77.99	62.39	74.76
75.000%	86.16	68.92	83.96
80.000%	96.69	77.36	96.45
85.000%	113.17	90.54	115.94
90.000%	141.36	113.09	148.30
95.000%	217.60	174.08	234.08
98.000%	419.13	335.30	461.28
99.000%	657.43	525.94	710.88
99.500%	966.98	773.59	1,035.70
99.997%	4,242.06	3,393.65	4,448.70

Broad River Basin - Simbase (Current Conditions) Scenario
Baseline - Natural Flows
Kings Mountain Reservoir (600.610)
IndexB Approach (10% - 90%)

Month/Period	Number of Days Flows < 80%	% of Days Flows < 80%	Average Deficit, cfs	Average Deficit, % Diff
1	96	4.647%	0.26	0.804%
2	109	5.867%	0.24	0.754%
3	106	5.389%	0.34	0.813%
4	506	23.947%	0.77	1.836%
5	1,015	45.011%	1.58	4.646%
6	1,176	58.247%	2.49	7.148%
7	1,189	61.992%	3.31	9.986%
8	1,184	66.071%	3.48	10.699%
9	1,121	67.612%	2.73	9.119%
10	948	52.872%	1.69	5.905%
11	472	23.529%	0.87	2.638%
12	122	5.722%	0.37	1.013%
Spring (4-6)	2,697	42.226%	1.60	4.507%
Summer (7-9)	3,494	65.089%	3.19	9.956%
Fall (10-11)	1,420	37.378%	1.26	4.180%
Winter (12-3)	433	5.397%	0.33	0.902%
P-O-R	8,044	34.118%	1.46	4.450%

80% Flow-By - Comments

- Most of the impacts occurred between Natural and Current Conditions.
- Measures small addition impacts between Current Conditions and projected 2060 scenario conditions.
- IndexB approach 85% (22 out of 27) no potential impact.

Questions

80% Flow-By
vs.
20% 7Q10

5-13-2013

Ecological Flow Science Advisory Board

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NC Department of Environment and Natural Resources

Disclaimer

- DWR is not assuming that the “80% Flow-By” approach will be the SAB’s final recommendation.
- Goal of analysis is to test a potential ecologic integrity planning criteria.
- The purpose of this presentation is to provide an example of “one” approach that could be used to implement a Flow-By approach.

How is 20% 7Q10 used?

- **20% 7Q10 is a SEPA minimum criteria for additional study.**
  - **If the maximum instantaneous with is less than 20% 7Q10 then no additional analysis is needed.**
- **20% 7Q10 has frequency been misapplied as the safe yield.**

Implementation Problem With 20% 7Q10

- Best application is a single isolated run-of-river withdrawal.
- Does not work for withdrawals from reservoirs.
- How to apply to multiple near by withdrawals?
- Does not provide a metric to assess the accumulative upstream impacts.
  - Only applies to run-of-river nodes with a withdrawal.

Trial Implementation of 80% Flow-By

- Need an approach that will work for single, multiple near-by, and reservoir withdrawals.
- Needs to be able to assess the accumulative upstream impacts at all flow nodes, work at nodes with or without withdrawals.

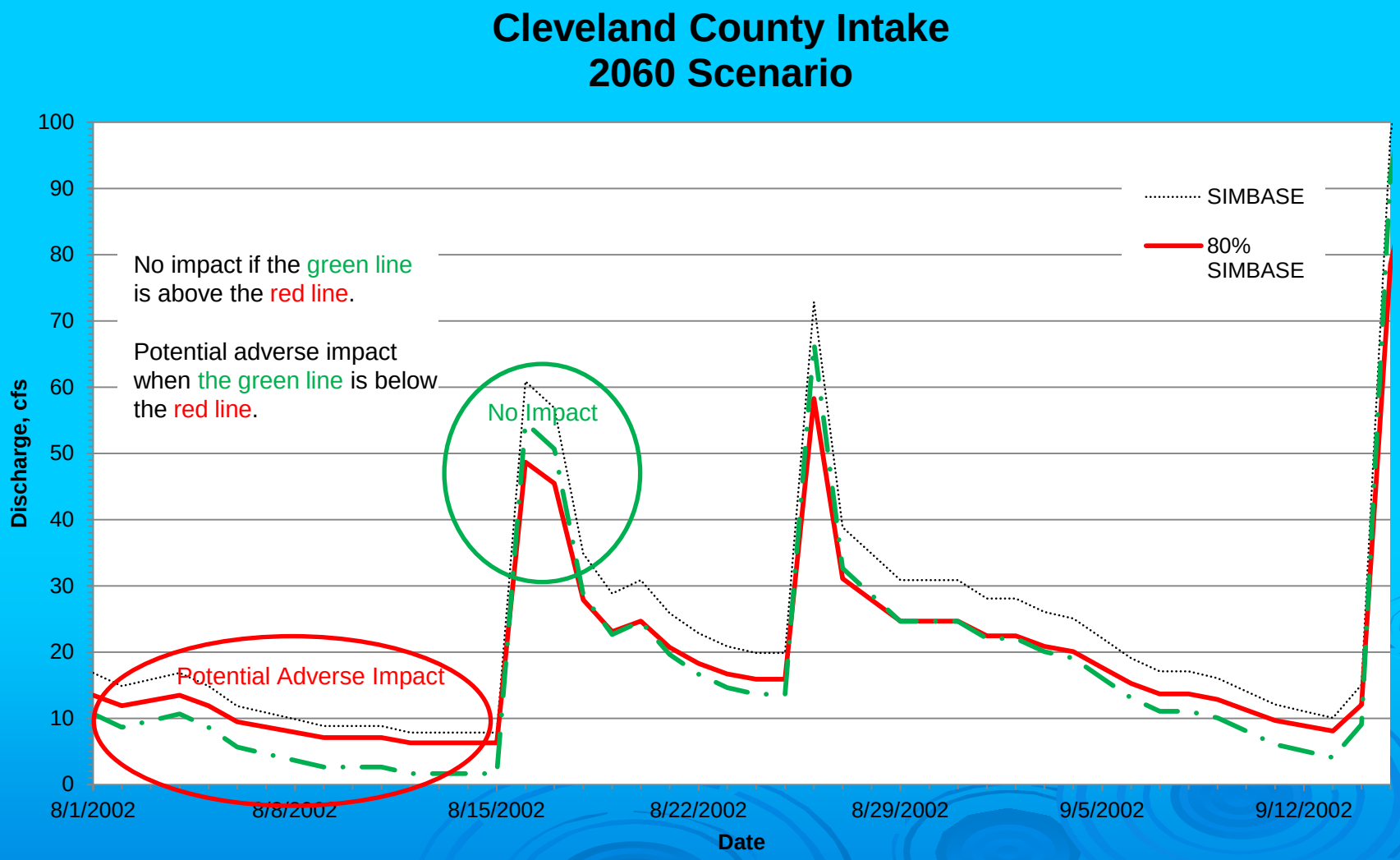
Starting Point

- **SL 2010-143 Definitions**
  - **"Ecological integrity"** means the ability of an aquatic system to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization **comparable to prevailing ecological conditions** and, when subject to disruption, to recover and continue to provide the natural goods and services that normally accrue from the system.
  - **"Prevailing ecological conditions"** means the ecological conditions determined by reference to the applicable period of record of the United States Geological Survey stream gauge data**, including data reflecting the ecological conditions that exist after the construction and operation of existing flow modification devices, such as dams**, but excluding data collected when stream flow is temporarily affected by in-stream construction activity.
- **Analysis Assumption**
  - Assume the **SIMBASE** modeling scenario represents “Prevailing ecological conditions”. SIMBASE is the model scenario that represents current conditions, withdrawals, discharges, reservoir operations, drought plans, etc.

80% Flow-By Analysis Approach

- **Create an 80% BASELINE using SIMBASE and compare scenarios to the baseline. When a scenario flow is below the BASELINE, that represents a potential adverse ecological impact.**
- **Analysis steps:**
  1. For each day (29,493 days)
     BASELINE = 80% * SIMBASE (outflow from the arc)
  2. Compare each day (29,493 days)
     IF scenario < BASELINE then that days is a potential adverse ecological impact day.
  3. Looking for guidance on how to assess if a node is adversely impacted based on number of days, time of year, etc.

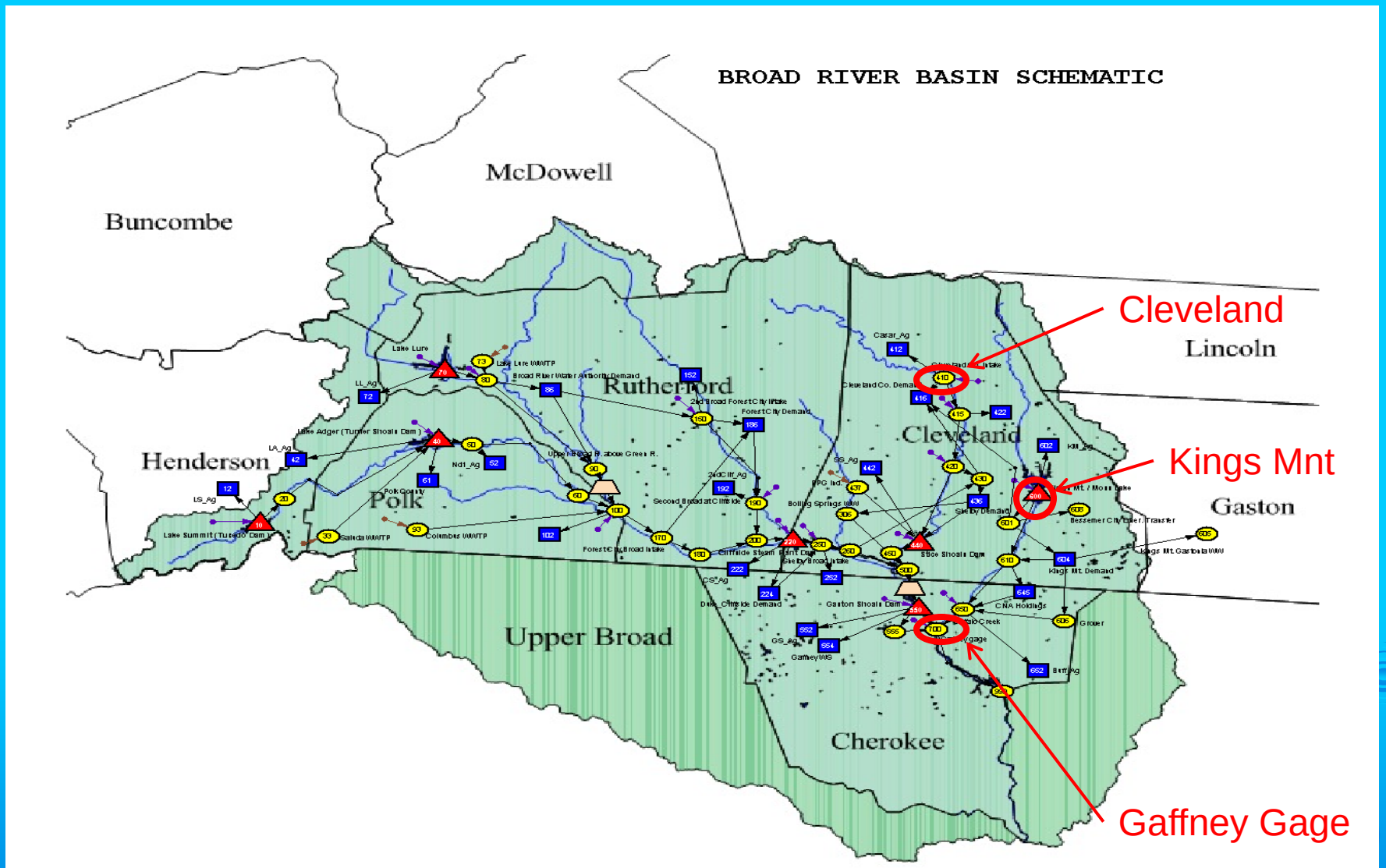
80% Flow-By Example



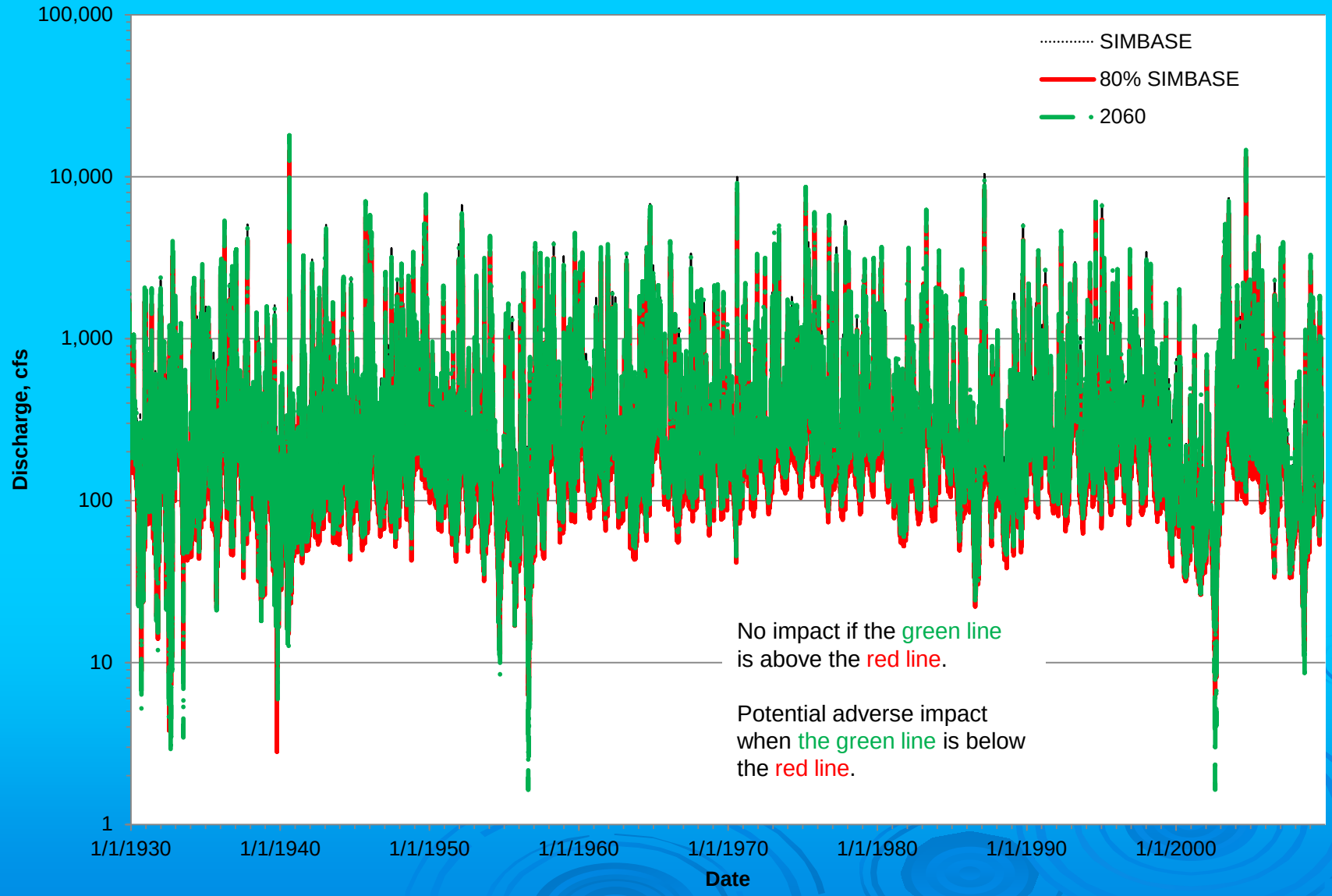
Trial Balloon

- **Broad River Basin**
  - **Only certified model**
  - **One of the smaller and simpler basins.**
  - **Has a mix of withdrawals both run-of-river and reservoir.**
  - **Analyzed 27 river nodes, this include the reservoir release nodes with a modeling record of 1/1/1930 to 12/31/2009.**

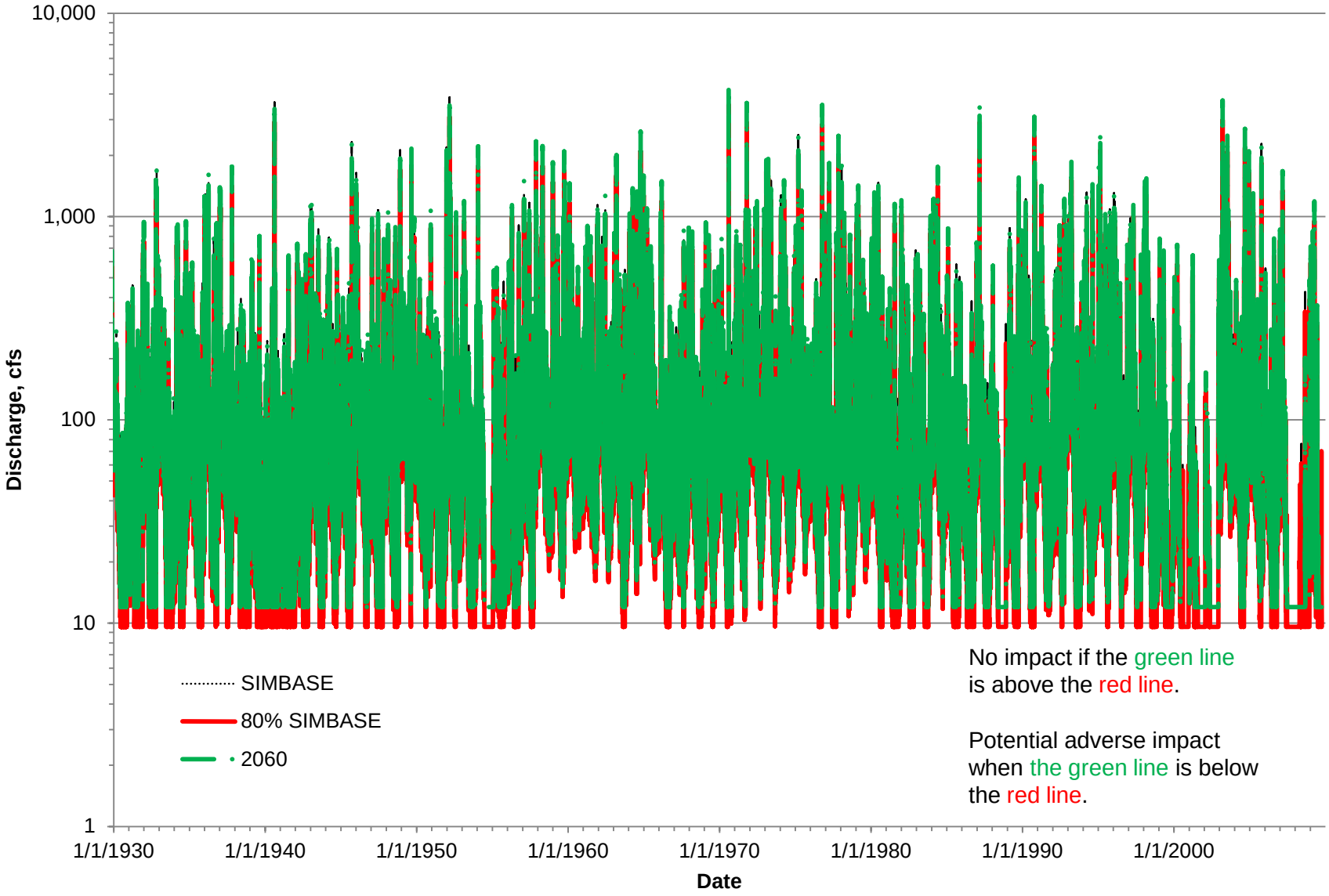
Broad River Basin Model



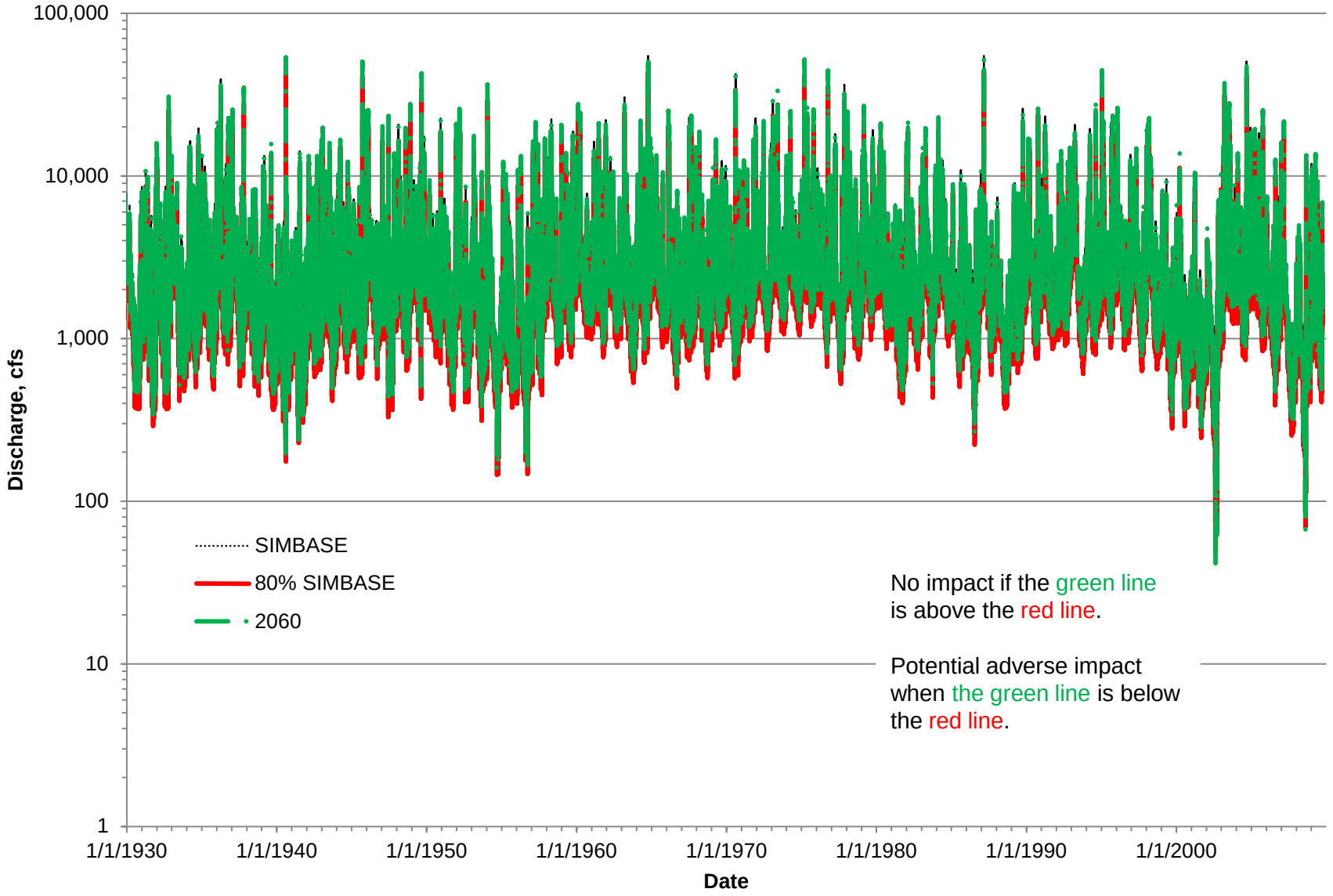
Cleveland County Intake
2060 Scenario



Kings Mnt Reservoir Release
2060 Scenario



Gaffney Gage
2060 Scenario



Broad River Basin - 2060 Scenario Node Summary

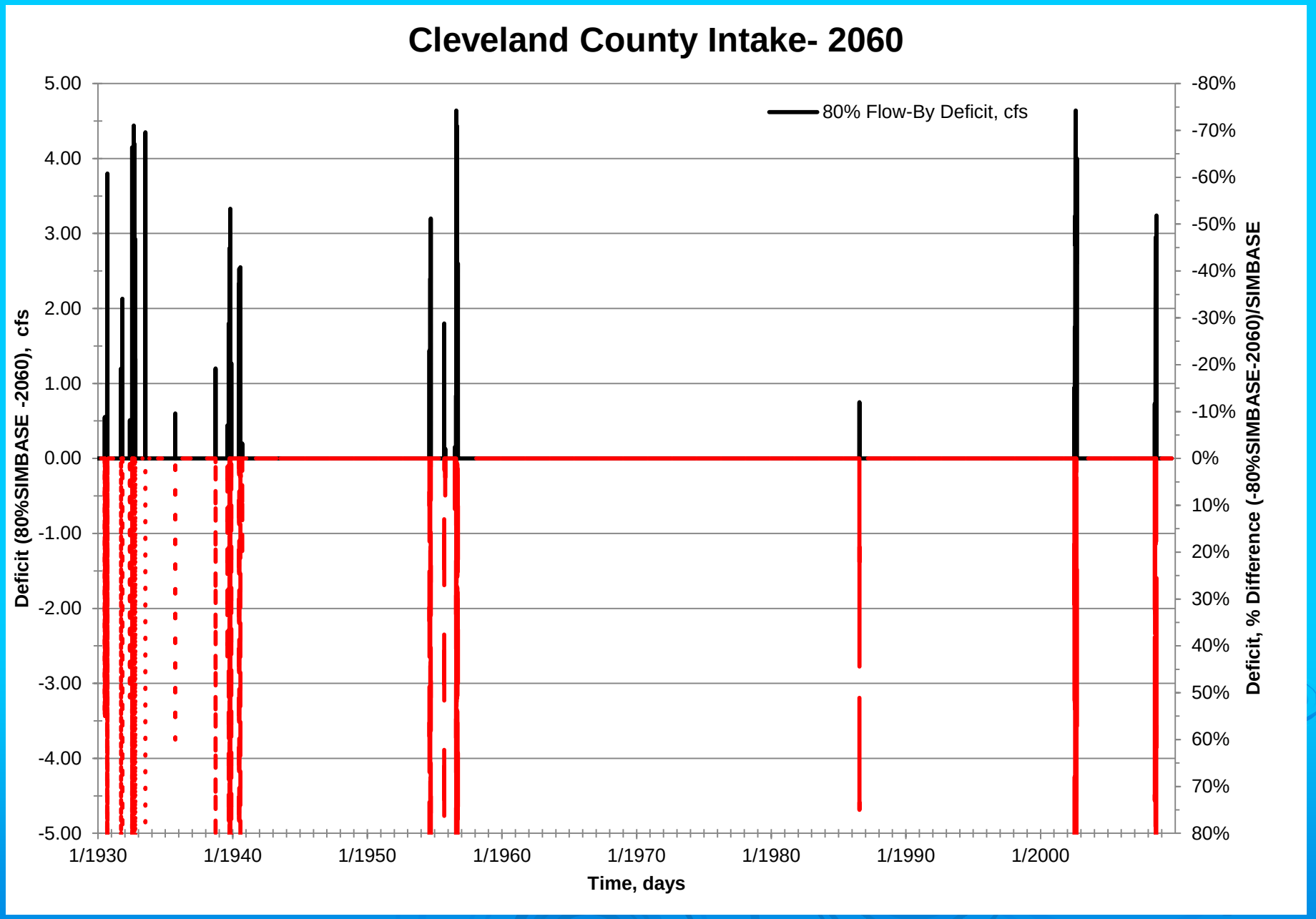
		80% of Flow-By	
Arc Node	Description of the Node	Number of days with potential adverse impacts	Percent of days
010.020	Lake Summit Release	0	0.00%
020.040	Green River to Lake Adger	0	0.00%
040.050	Lake Adger Release	168	0.57%
050.060	Green River to Ken Miller	168	0.57%
060.100	Green River to Broad Confluence	168	0.57%
070.080	Lake Lure Release	0	0.00%
080.090	Upper Broad	30	0.10%
090.100	Upper Broad to Broad Confluence	24	0.08%
100.170	Broad River to Forest City Intake	4	0.01%
150.190	2nd Broad	18	0.06%
190.200	2nd Broad Cliffside	0	0.00%
170.180	Forest City Intake (2nd Broad)	4	0.01%
180.200	Upper Cliffside	4	0.01%
200.220	2nd Broad Confluence	0	0.00%
220.250	Cliffside Dam Release	25	0.08%
250.260	Boiling Spring Gage	4	0.01%
410.415	Cleveland Intake	159	0.54%
415.420	Lawndale Gage	116	0.39%
420.440	Shelby Intake (1st Broad)	131	0.44%
440.450	Gaston Shoals Dam Release	0	0.00%
450.500	First Broad Confluence	0	0.00%
500.550	Lower Broad	4	0.01%
550.700	Gaston Shoals Dam Release	104	0.35%
600.610	Kings Mountain Reservoir Release	290	0.98%
610.650	Kings Mountain WTP Discharge	163	0.55%
650.700	Buffalo Creek Confluence	50	0.17%
700.999	Gaffney Gage	26	0.09%

74% of the nodes (20 out 27) with 1 or more days with potential impacts.
Potential impacts occur less than 1% of the time.

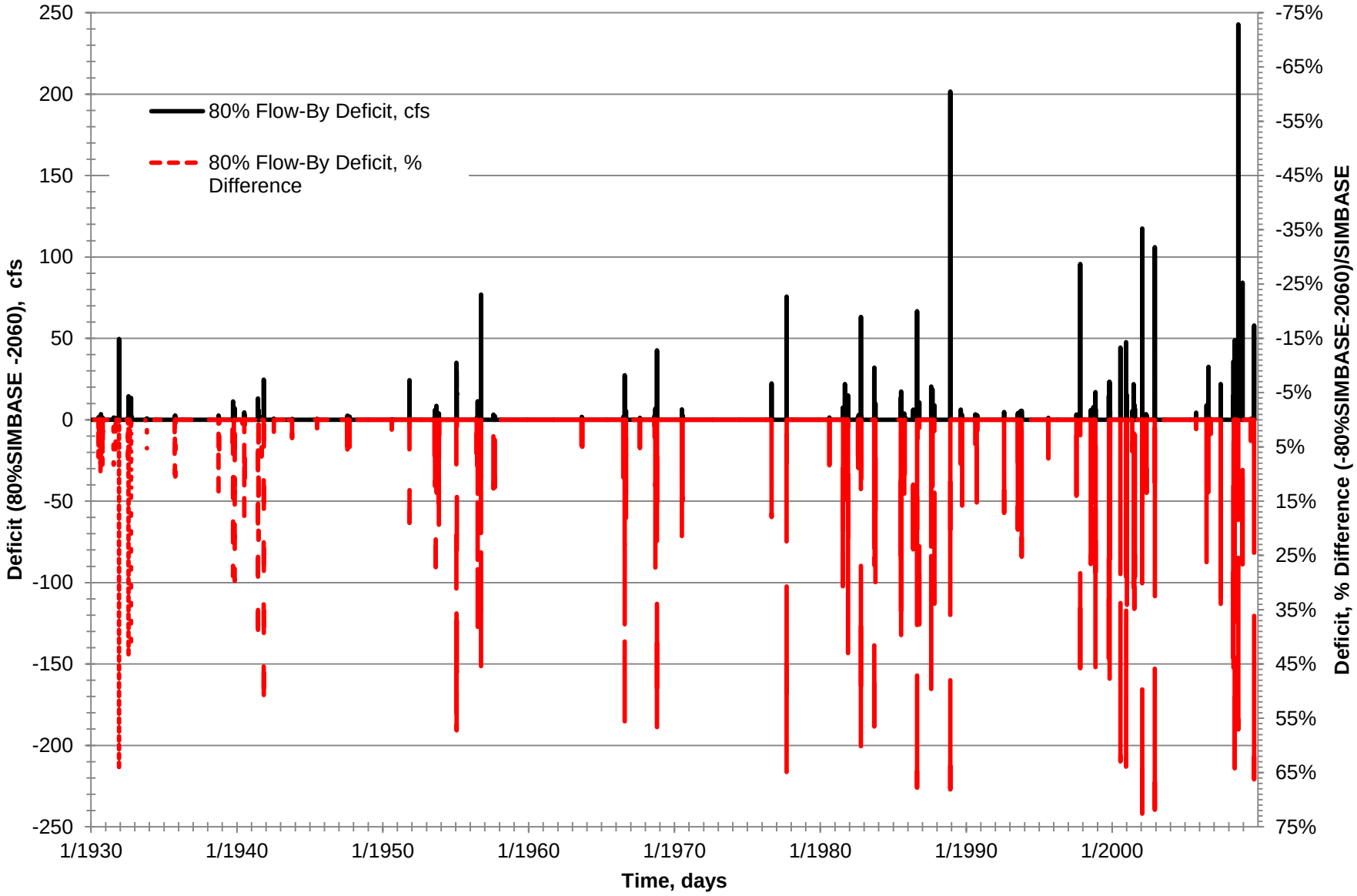
Broad River Basin - 2060 Scenario
80% of Flow-By Summary

		Days Potential Impact		Difference (2060-80%SIMBASE), cfs			
Arc Node	Description of the Node	Number of days	Percent of days	Minimum	Average	Median	Maximum
410.415	Cleveland Intake	159	0.54%	0.00	0.01	0.00	4.64
600.610	Kings Mountain Reservoir Release	290	0.98%	0	0.11	0	242.83
700.999	Gaffney Gage	26	0.09%	0.00	0.01	0.00	32.61
	Average of the 27 Nodes	61	0.21%				

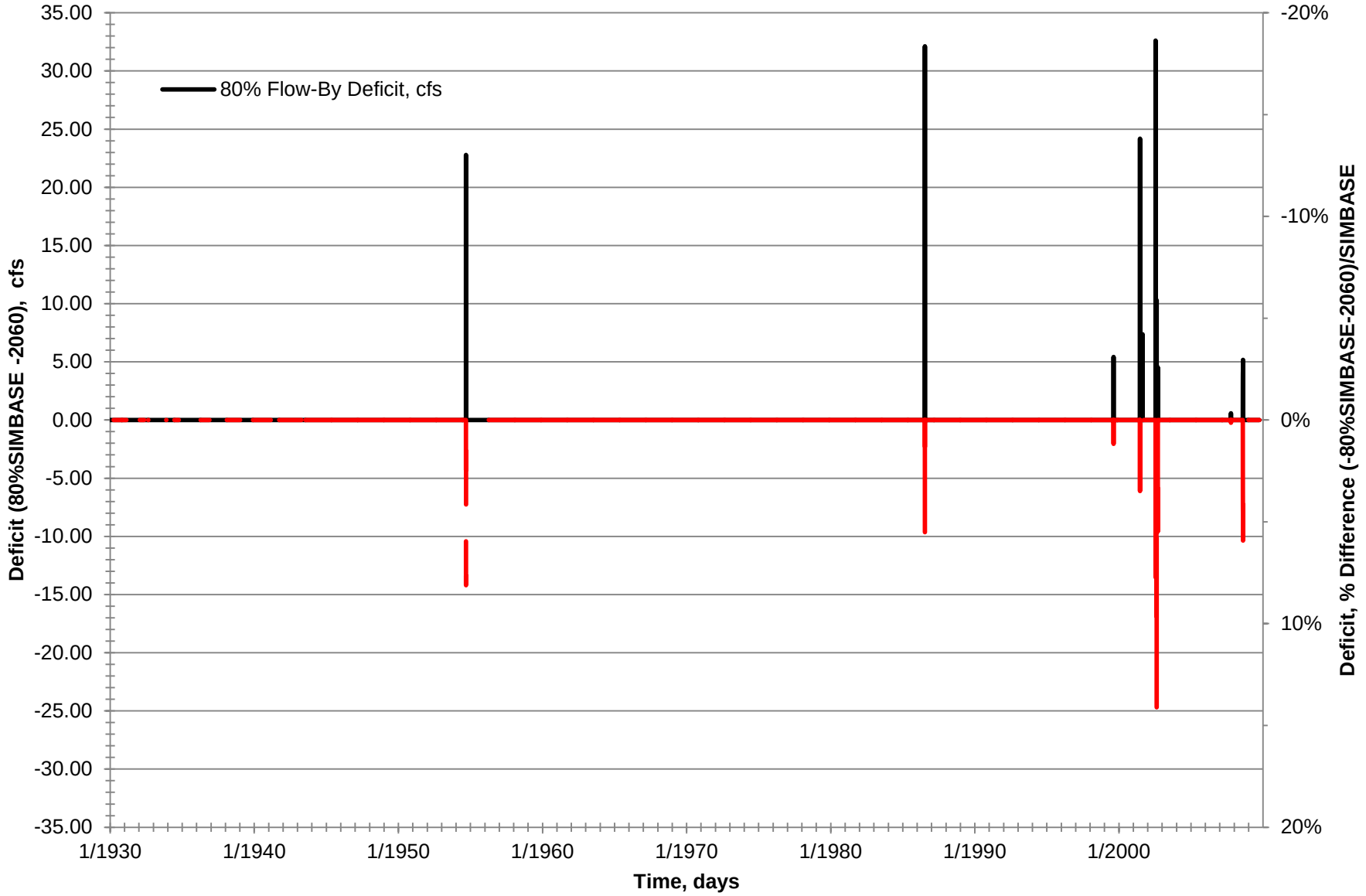
		Difference (2060-80%SIMBASE), cfs			
		Minimum	Average	Median	Maximum
410.415	Cleveland Intake	0.00%	0.08%	0.00%	80.00%
600.610	Kings Mountain Reservoir Release	0.00%	0.20%	0.00%	72.59%
700.999	Gaffney Gage	0.00%	0.01%	0.00%	16.46%


Cleveland County Intake- 2060
80% Flow-By Deficit, cfs
Deficit (80%SIMBASE -2060), cfs
Deficit, % Difference (-80%SIMBASE-2060)/SIMBASE
Time, days
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-80%
-70%
-60%
-50%
-40%
-30%
-20%
-10%
0%
10%
20%
30%
40%
50%
60%
70%
80%
1/1930
1/1940
1/1950
1/1960
1/1970
1/1980
1/1990
1/2000

Kings Mnt Reservoir Release - 2060



Gaffney Gage - 2060



Broad River Basin - 2060 Scenario - 80% of Flow-By Frequency Analysis

Non-Exceedence	Cleveland Intake cfs		Kings Mountain Reservoir Release cfs		Gaffney Gage cfs	
Percent	80%SIMBASE	2060	80%SIMBASE	2060	80%SIMBASE	2060
0.003%	2.81	0.00	9.60	12.00	50.05	39.76
0.500%	23.80	23.44	9.60	12.00	278.08	323.90
1.000%	30.46	32.06	9.60	12.00	364.80	442.81
2.000%	38.46	42.13	9.60	12.00	396.62	485.32
5.000%	50.28	56.89	9.60	12.00	561.44	682.26
10.000%	66.46	77.13	9.60	12.00	720.60	876.10
15.000%	78.07	91.89	11.84	12.14	831.03	1,015.71
20.000%	87.00	102.98	16.20	18.27	933.17	1,144.17
25.000%	94.86	112.89	20.02	23.12	1,025.51	1,259.31
30.000%	103.01	123.14	23.41	27.49	1,115.89	1,373.37
35.000%	112.13	134.44	26.96	32.15	1,207.28	1,487.16
40.000%	121.40	146.09	30.60	36.56	1,292.03	1,593.01
45.000%	130.48	157.30	34.28	41.23	1,385.76	1,709.70
50.000%	140.08	169.34	38.61	46.72	1,487.14	1,837.53
55.000%	150.48	182.30	43.05	52.22	1,598.96	1,977.31
60.000%	162.19	197.09	48.16	58.59	1,719.80	2,128.53
65.000%	174.99	213.09	53.65	65.52	1,843.28	2,283.46
70.000%	190.48	232.28	59.81	73.28	1,996.54	2,474.56
75.000%	209.73	256.98	67.17	82.35	2,183.80	2,707.04
80.000%	235.79	289.23	77.16	94.89	2,432.98	3,019.67
85.000%	272.83	335.27	92.75	114.22	2,790.52	3,466.91
90.000%	334.48	412.28	118.64	146.41	3,393.62	4,220.36
95.000%	497.03	615.52	187.26	231.59	4,886.97	6,088.46
98.000%	868.27	1,080.09	369.03	458.72	7,920.52	9,881.02
99.000%	1,339.84	1,669.31	568.70	709.43	11,190.51	13,968.40
99.500%	1,938.71	2,417.33	828.56	1,034.32	14,958.05	18,676.93
99.997%	14,402.30	17,996.62	3,558.96	4,446.98	43,746.91	54,661.96

Red cells are 2060 flows a potential adverse impact.

We Need Help With -

- **How do we implement your recommendation?**
  - **If a flow-by approach is used, is the analysis on the right path?**
  - **Is SIMBASE the correct starting point?**
  - **Do all flows need to be ≥ 80% of SIMBASE?**
  - **Are certain times of the year or specific flow ranges of more importance?**
  - **?**

Questions

80% flow-by is a trial balloon DWR is open willing to consider all recommendations from the SAB, including variations on the 80% theme.

Contact Information

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