

Saluda Hydro Proposed Guide Curve & Low Inflow Protocol

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SCE&G Fossil Hydro

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Topics

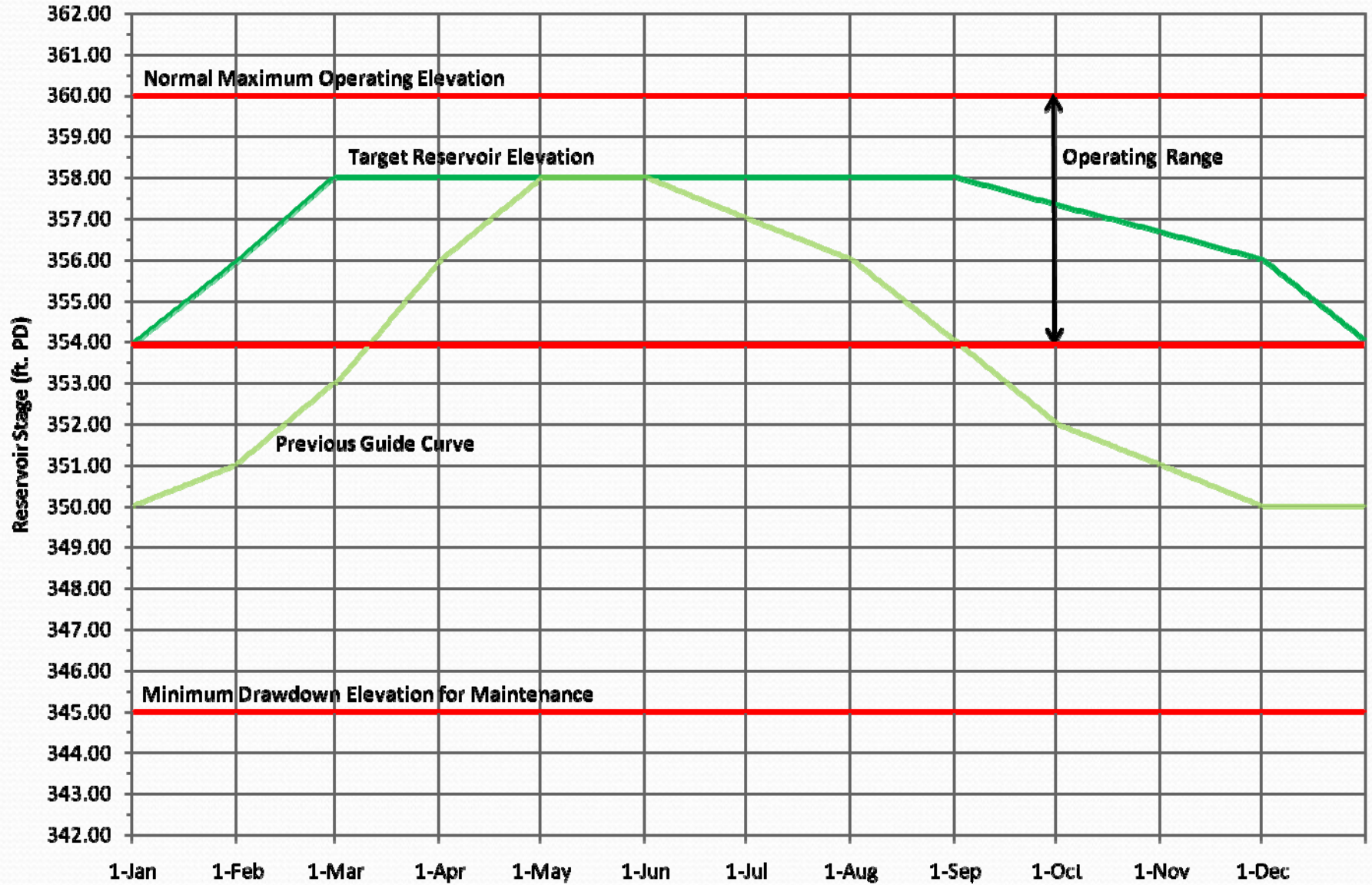
- Proposed Reservoir Guide Curve for Saluda Hydro
 - Purpose & Definitions
- Proposed Low Inflow Protocol for Saluda Hydro
 - Purpose
 - Definitions
 - How it works

Proposed Reservoir Guide Curve

Purpose

- To provide a set of target reservoir elevations which guides SCE&G's operation of the reservoir throughout the year.
- Not intended as a “rule curve” – provides an operating range between el. 354.0 ft. PD and el 360.0 ft. PD to provide flexibility under various operating conditions.
- Normal maximum reservoir elevation of 358.0 ft. PD.
- Minimum reservoir elevation of 345.0 ft. PD for maintenance activities.

Saluda Hydro Proposed Guide Curve



Saluda Hydro Proposed Guide Curve Table

	January	February	March	April	May	June	July	August	September	October	November	December
1	354.00	356.00	358.00	358.00	358.00	358.00	358.00	358.00	358.00	357.33	356.67	356.00
2	354.06	356.07	358.00	358.00	358.00	358.00	358.00	358.00	357.98	357.31	356.65	355.94
3	354.13	356.14	358.00	358.00	358.00	358.00	358.00	358.00	357.96	357.29	356.63	355.87
4	354.19	356.21	358.00	358.00	358.00	358.00	358.00	358.00	357.93	357.27	356.60	355.81
5	354.26	356.29	358.00	358.00	358.00	358.00	358.00	358.00	357.91	357.24	356.58	355.74
6	354.32	356.36	358.00	358.00	358.00	358.00	358.00	358.00	357.89	357.22	356.56	355.68
7	354.39	356.43	358.00	358.00	358.00	358.00	358.00	358.00	357.87	357.20	356.54	355.61
8	354.45	356.50	358.00	358.00	358.00	358.00	358.00	358.00	357.84	357.18	356.51	355.55
9	354.52	356.57	358.00	358.00	358.00	358.00	358.00	358.00	357.82	357.16	356.49	355.48
10	354.58	356.64	358.00	358.00	358.00	358.00	358.00	358.00	357.80	357.14	356.47	355.42
11	354.65	356.71	358.00	358.00	358.00	358.00	358.00	358.00	357.78	357.12	356.45	355.35
12	354.71	356.79	358.00	358.00	358.00	358.00	358.00	358.00	357.75	357.10	356.42	355.29
13	354.77	356.86	358.00	358.00	358.00	358.00	358.00	358.00	357.73	357.07	356.40	355.23
14	354.84	356.93	358.00	358.00	358.00	358.00	358.00	358.00	357.71	357.05	356.38	355.16
15	354.90	357.00	358.00	358.00	358.00	358.00	358.00	358.00	357.69	357.03	356.36	355.10
16	354.97	357.07	358.00	358.00	358.00	358.00	358.00	358.00	357.67	357.01	356.34	355.03
17	355.03	357.14	358.00	358.00	358.00	358.00	358.00	358.00	357.64	356.99	356.31	354.97
18	355.10	357.21	358.00	358.00	358.00	358.00	358.00	358.00	357.62	356.97	356.29	354.90
19	355.16	357.29	358.00	358.00	358.00	358.00	358.00	358.00	357.60	356.95	356.27	354.84
20	355.23	357.36	358.00	358.00	358.00	358.00	358.00	358.00	357.58	356.93	356.25	354.77
21	355.29	357.43	358.00	358.00	358.00	358.00	358.00	358.00	357.55	356.90	356.22	354.71
22	355.35	357.50	358.00	358.00	358.00	358.00	358.00	358.00	357.53	356.88	356.20	354.65
23	355.42	357.57	358.00	358.00	358.00	358.00	358.00	358.00	357.51	356.86	356.18	354.58
24	355.48	357.64	358.00	358.00	358.00	358.00	358.00	358.00	357.49	356.84	356.16	354.52
25	355.55	357.71	358.00	358.00	358.00	358.00	358.00	358.00	357.46	356.82	356.13	354.45
26	355.61	357.79	358.00	358.00	358.00	358.00	358.00	358.00	357.44	356.80	356.11	354.39
27	355.68	357.86	358.00	358.00	358.00	358.00	358.00	358.00	357.42	356.78	356.09	354.32
28	355.74	357.93	358.00	358.00	358.00	358.00	358.00	358.00	357.40	356.76	356.07	354.26
29	355.81	357.93	358.00	358.00	358.00	358.00	358.00	358.00	357.37	356.73	356.04	354.19
30	355.87		358.00	358.00	358.00	358.00	358.00	358.00	357.35	356.71	356.02	354.13
31	355.94		358.00		358.00		358.00	358.00		356.69		354.06

Proposed Reservoir Guide Curve

- SCE&G will strive to operate within the operating range under “normal” conditions.
- Reservoir may be above or below target elevation (guide curve) at a given time, based on actual or forecast inflow, system reserve requirements, minimum flow and scheduled releases, etc.
- Maintenance activities or low inflow conditions may require operation outside the operating range.
- Plant may be available for reserve operations whenever reservoir is above el. 345.0 PD.

Proposed Low Inflow Protocol

Purpose

- To allow staged reductions in minimum flow and other releases during periods of drought and low inflows to the reservoir.
- Conserves storage in the reservoir to delay the reservoir reaching el. 345.0 ft. PD, which is the critical elevation for most municipal water intakes on Lake Murray, and is the license minimum for SCE&G.
- “Shares the pain” of drought conditions between upstream and downstream interests, and preserves a critical level of flow downstream.

Proposed Low Inflow Protocol

L.I.P. Definitions

- “Usable Storage” - the storage available between el. 345.0 Plant Datum (PD) and el. 360.0 PD, which equals about 635,000 acre-feet.
- “Remaining Usable Storage” (RUS) – the water in storage in acre-feet above el. 345.0 PD remaining at any given time.
- “Target Usable Storage” (TUS) – the storage value in acre-feet above el. 345.0 corresponding to the target reservoir elevation for any given day of the year.
 - For example, on February 1, the target reservoir elevation is 356.0 ft. PD, and the TUS is 442,383 ac-ft.

Proposed Low Inflow Protocol

L.I.P. Definitions (cont'd.)

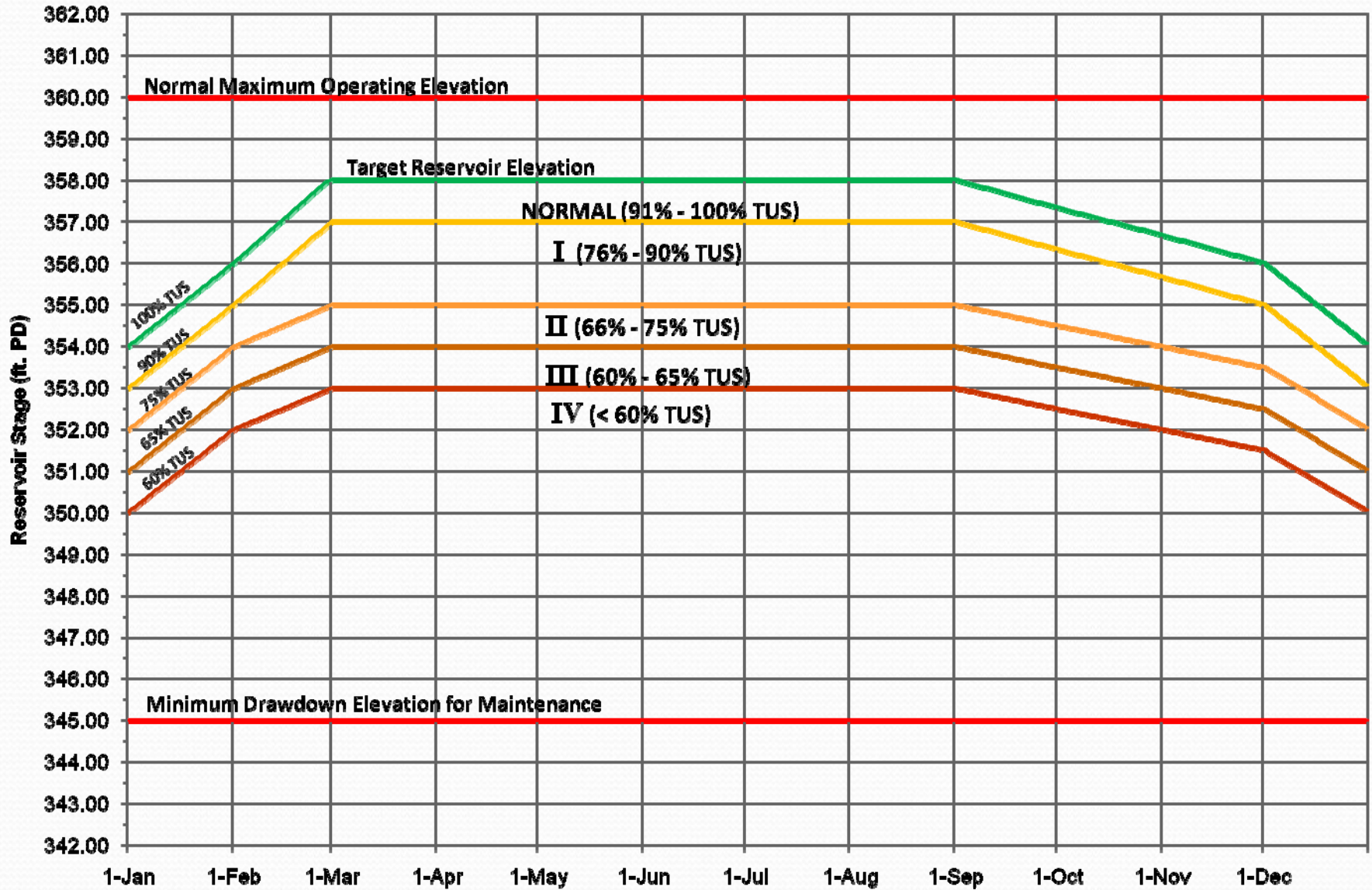
- “Percent TUS” – the ratio of Remaining Usable Storage (RUS) to Target Usable Storage (TUS) at a given time, expressed as a percentage.
 - Example – On March 22, the actual reservoir elevation is 356.80 ft. PD, which gives RUS value of 479,414 ac-ft. The target reservoir elevation for that day is 358.0 ft. PD, and the TUS is 536,341 ac-ft. The % TUS is $(479,414/536,341) \times 100\% = \mathbf{89.4\%}$.

Proposed Low Inflow Protocol

L.I.P. Overview

- Four L.I.P stages (I – IV) based on:
 - Percent TUS – primary index
 - U. S. Drought Monitor value for Saluda River Basin upstream of Lake Murray.
 - USGS 28 day percentile rank for three gauge stations:
 - Saluda River at Chappells, USGS No. 02167000
 - Little River near Silverstreet, USGS No. 02167450
 - Bush River near Prosperity, USGS No. 02167582

Saluda Hydro Proposed Guide Curve with L.I.P. Trigger Bands



Monthly Reservoir Operation Targets and Low Inflow Protocol Trigger Levels

Month	Target Stage (ft. PD)	Target Usable Storage TUS (ac-ft)	90% TUS Stage	75% TUS Stage	65% TUS Stage	60% TUS Stage
January 1st	354.0	352,925	353.0	352.0	351.0	350.0
February 1st	356.0	442,383	355.0	354.0	353.0	352.0
March 1st	358.0	536,341	357.0	355.0	354.0	353.0
April 1st	358.0	536,341	357.0	355.0	354.0	353.0
May 1st	358.0	536,341	357.0	355.0	354.0	353.0
June 1st	358.0	536,341	357.0	355.0	354.0	353.0
July 1st	358.0	536,341	357.0	355.0	354.0	353.0
August 1st	358.0	536,341	357.0	355.0	354.0	353.0
September 1st	358.0	536,341	357.0	355.0	354.0	353.0
October 1st	357.3	504,350	356.3	354.5	353.5	352.5
November 1st	356.7	473,347	355.7	354.0	353.0	352.0
December 1st	356.0	442,383	355.0	353.5	352.5	351.5

U. S. Drought Monitor Value

Return to [U.S. Drought Monitor](#) Return to [Region](#)

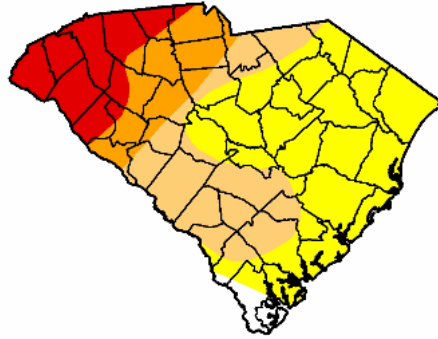
The data cutoff for Drought Monitor maps is Tuesday at 7 a.m. Eastern Standard Time. The maps, which are based on analysis of the data, are released each Thursday at 8:30 a.m. Eastern Time.

U.S. Drought Monitor South Carolina

May 13, 2008
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	2.2	97.8	51.9	28.3	15.2	0.0
Last Week (05/06/2008 map)	2.2	97.8	51.9	28.3	14.3	0.0
3 Months Ago (02/19/2008 map)	0.2	99.8	92.8	67.4	40.1	15.7
Start of Calendar Year (01/01/2008 map)	1.0	99.0	95.3	76.5	41.9	19.5
Start of Water Year (10/02/2007 map)	9.9	90.1	82.0	65.6	42.7	18.3
One Year Ago (05/15/2007 map)	0.0	100.0	31.7	1.7	0.0	0.0



Intensity:

- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements

<http://drought.unl.edu/dm>

For a pdf version of the South Carolina Drought Monitor, click [here](#).

To view tabular statistics for South Carolina, click [here](#).

For more information on the Drought Impact Reporter click [here](#).

For local details and impacts, please contact your [State Climatologist](#) or [Regional Climate Center](#).



Released Thursday, May 15, 2008
Author: Michael James, JAWF/CPC/NOAA

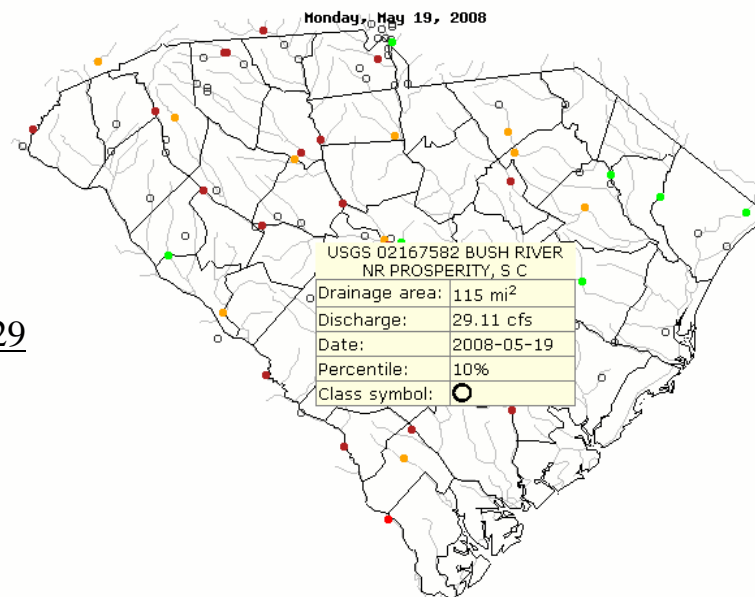
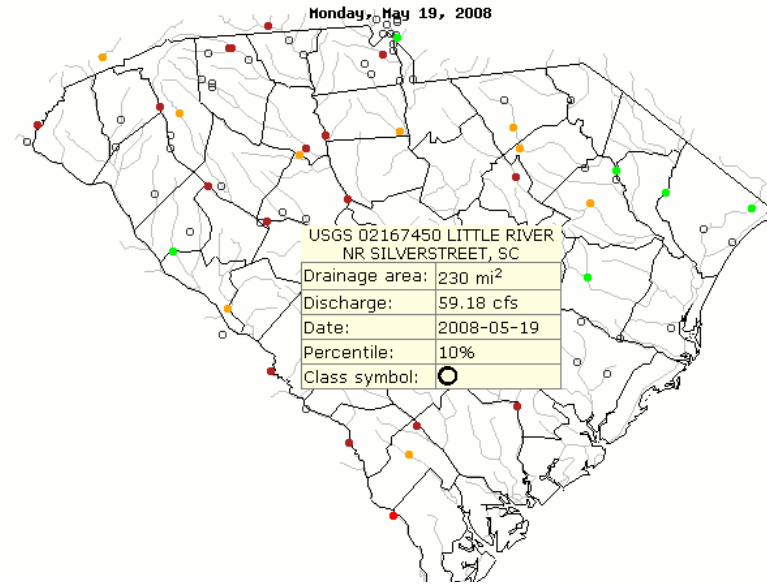
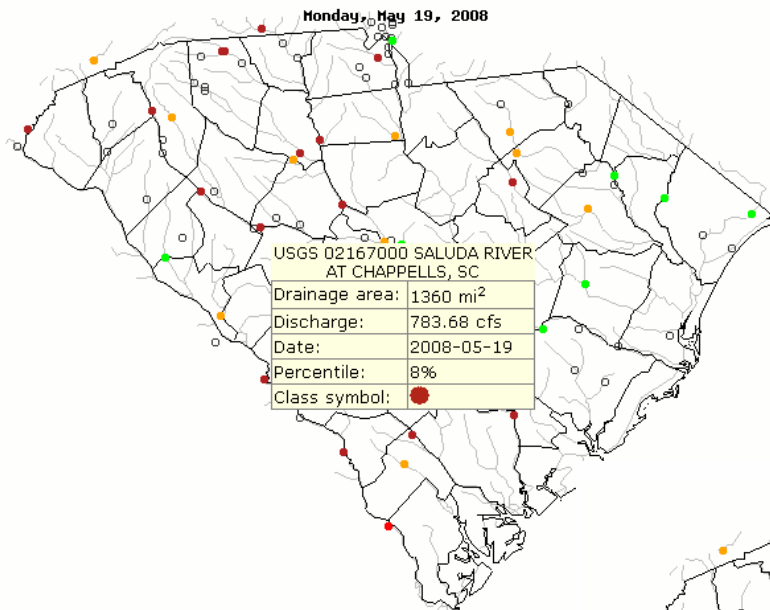
- None (SC "Normal")
- D0 Abnormally Dry (SC "Incipient")
- D1 Moderate
- D2 Severe
- D3 Extreme

USDM "D4 Exceptional" is not used in the Saluda L.I.P.

Highest USDM Value in effect in the Saluda River basin upstream of Lake Murray will be used as the L.I.P. trigger index.

USGS Percentile Rank Example

Map of 28-day average streamflow compared to historical streamflow for the day of the year (South Carolina)



Weighted Percentile Rank for 3 Gauges:
 $(8\% \times 784 \text{ CFS} + 10\% \times 59 \text{ CFS} + 10\% \times 29 \text{ CFS})$

$$= \frac{(784 + 59 + 29) \times 0.08}{784 + 59 + 29} = 8.2\%$$

Proposed Low Inflow Protocol Trigger Points & Actions

LIP Stage	Percent Target Usable Storage ¹		U.S. Drought Monitor Value ²		USGS 28 Day Streamflow Percentile ³	Minimum Flows	Recreation Flow Reductions
Normal	90% TUS < RUS ≤ 100% TUS	AND	None	AND	≥ 25%	4/1 - 4/14: 1,000 CFS 4/15 - 5/14: 1,300 CFS 5/15 - 5/31: 1,000 CFS Rest of Year: 700 CFS	None
I	75% TUS < RUS ≤ 90% TUS	AND	D0	OR	15% - 24%	4/1 - 4/14: 700 CFS 4/15 - 5/14: 1,300 CFS 5/15 - 5/31: 700 CFS Rest of Year: 600 CFS	To Be Determined
II	65% TUS < RUS ≤ 75% TUS	AND	D1	OR	10% - 14%	4/1 - 4/14: 700 CFS 4/15 - 5/14: 700 CFS, pulse to 1,300 CFS 5/15 - 5/31: 700 CFS Rest of Year: 500 CFS	To Be Determined
III	60% TUS < RUS ≤ 65% TUS	AND	D2	OR	5% - 9%	4/1 - 4/14: 400 CFS 4/15 - 5/14: 400 CFS, pulse to 700 CFS 5/15 - 5/31: 400 CFS Rest of Year: 400 CFS	To Be Determined
IV	RUS ≤ 60% TUS	AND	≥ D3	OR	< 5%	4/1 - 4/14: 400 CFS 4/15 - 5/14: 400 CFS 5/15 - 5/31: 400 CFS Rest of Year: 400 CFS	To Be Determined

¹ "Percent Target Usable Storage" (%TUS) is the ratio of Remaining Usable Storage (RUS) to Target Usable Storage (TUS) expressed as a percentage.

² The highest U.S. Drought Monitor value (D0 – D3) in any part of the Saluda River Basin upstream of Lake Murray.

³ Weighted average percentile rank of the USGS 28 Day Average Streamflows at Saluda R. (Chappells), Little R. (Silverstreet), and Bush R. (Prosperity) gage sites.

Proposed Low Inflow Protocol

L.I.P. Summary

- L.I.P. triggers require below target storage and one of the other two indices meet criteria for a given stage to trigger that stage.
- This means that flow reductions will not be triggered until remaining storage falls to below 91% of target level, even if inflow drops or drought conditions begin in the basin.
- Shares benefits of reservoir upstream/downstream by using some storage to maintain minimum flows, then reducing flows to conserve remaining storage.

Proposed Low Inflow Protocol

L.I.P. Summary – Drought Recovery

- During a recovery from a drought, all three L.I.P. triggers must meet criteria for the previous stage before returning to that stage.
- This keeps flow reductions in effect to allow storage to be replenished as inflow increases.

Proposed Low Inflow Protocol

L.I.P. Current Year Example

- Started 2008 in Stage II, reservoir at el. 352.62 ft. PD, USDM D4, USGS percentile < 10%.
- Currently, reservoir elevation is 358.7, target elevation is 358.0 (would not have occurred with proposed minimum flows).
- TUS is 536,341 ac-ft, RUS is 570,363, %TUS is 106%.
- U. S. Drought Monitor value for Saluda Basin above Lake Murray is D3, corresponding to L.I.P. Stage IV.
- Flow weighted USGS 28 day percentile rank for the three gauge stations is 8%, corresponding to L.I.P. Stage III.
- **Since we started the year in Stage II, and USDM and USGS indices have not recovered to Stage I or Normal, we would still be in Stage II, even with current above target reservoir storage value.**

Proposed Low Inflow Protocol

L.I.P. Example – Later in The Summer?

- If USDM value stays at D3, and flow weighted USGS 28 day percentile rank for the three gauge stations stays below 10%, then if target elevation is 358.0 ft. PD:
- **L.I.P. Stage II in effect → Min. flow reduced to 500 CFS.**
- **L.I.P. Stage III would be triggered when reservoir drops to below el. 354.0 → Min. flow reduced to 400 CFS.**
- **L.I.P. Stage IV would be triggered when reservoir drops to below el. 353.0 → Min. flow 400 CFS.**

Proposed Low Inflow Protocol

Next Steps for L.I.P.

- Evaluate L.I.P. operation using historical drought status and USGS flows – does it track other indices well, or does it lead or lag them?
- Develop a Maintenance/Emergency Protocol to deal with deliberate reservoir drawdowns – needs to coordinate with L.I.P. to allow reservoir to refill.
- Continue to work with RCGs to determine/finalize flow reduction schedule during low inflow periods.



Questions?