# Preliminary Reservoir Safe Yield Results

**Kirk Westphal**

*Agenda Item 4b*

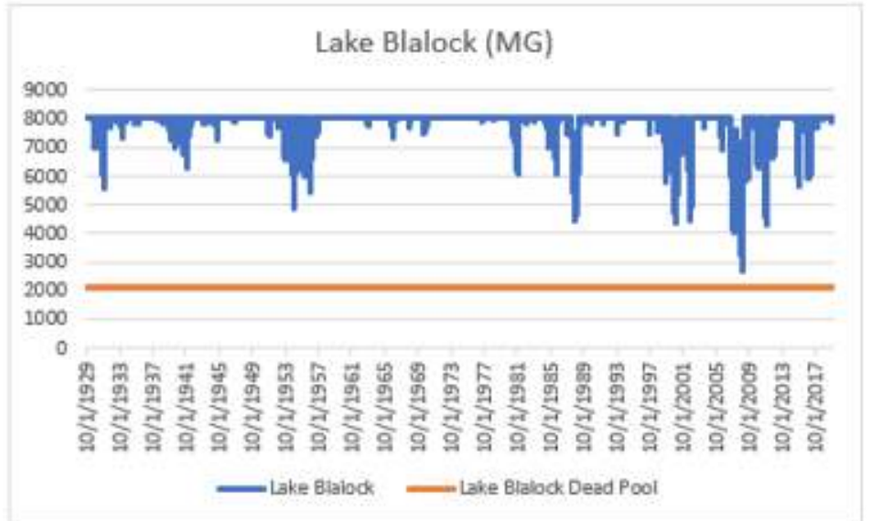
# Concepts and Purpose

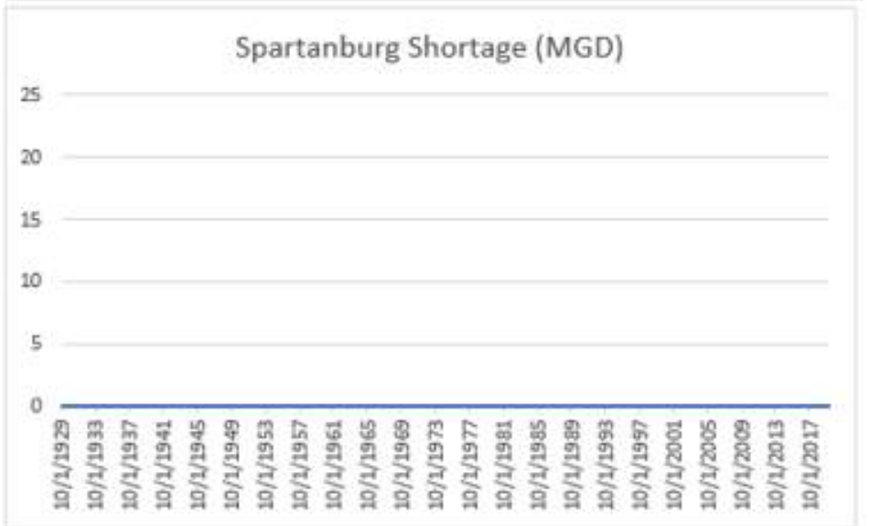
- **Safe Yield** = Maximum annual average demand that can be sustained through the period of record without depleting available storage (based on shallowest intake)
- **Reservoir Balancing**: In some cases, we can adjust rules so that reservoirs in a system draw down together at the same relative rate to avoid water in one but not others (for example)
- **Demand Assumptions**: Current / Permitted and Registered / **2070 High Demand**
- **Purpose:** Determine the amount of water that is physically/hydrologically available at a reservoir
- **Note:** Reservoir Safe Yield is DIFFERENT than basin safe yield used by SCDHEC for withdrawal permitting
  - **Reservoir Safe Yield:** Hypothetical maximum withdrawal volume used for planning
  - **Basin Safe Yield:** Statistical availability of free-flowing water in a river, used for permit evaluation

# Method

- Remove permit / intake / treatment constraints at the reservoir
- Suspend target elevation rules
- Maintain downstream release rules
- Apply appropriate demand scenarios upstream
- Consolidate withdrawals from the reservoir to a single hypothetical user at the reservoir
- Gradually increase continuous annual withdrawal (with seasonality) until:
  - lowest storage over period of record = dead pool / lowest allowable level
  - No Shortages

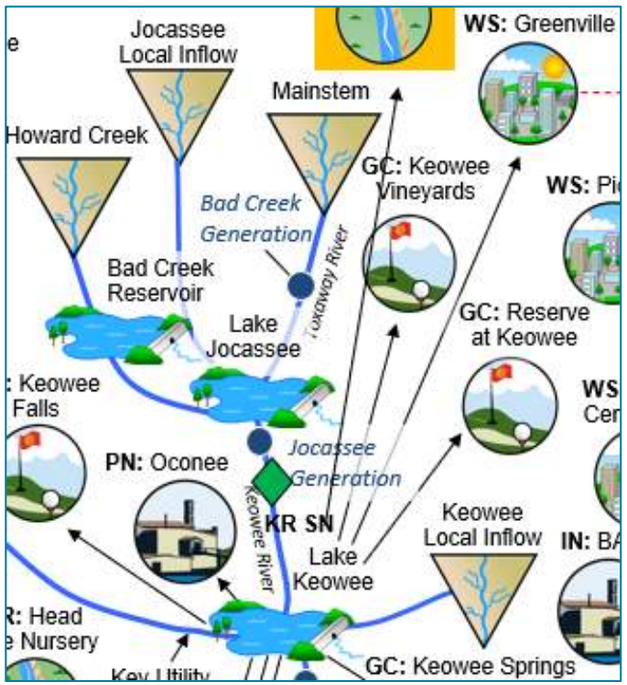
Example from Broad River Basin



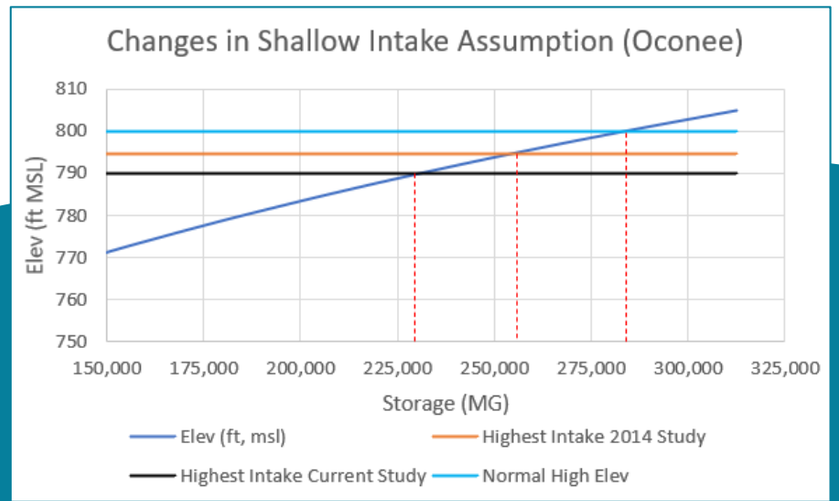



# Upper Reservoirs

Bad Creek Reservoir, Lake Jocassee, Lake Keowee




- Evaluated as a system of reservoirs in series
- Yield evaluated and reported at Keowee
- Deadpool based on Oconee Power Station intake at 790 ft
- All withdrawals consolidated to Greenville to maintain seasonality
- Greenville return flow re-routed downstream of Keowee
- All other users turned off




From 2014 Study: Safe Yield <69 MGD

# Intake Elevations and Prior Results

Keowee-Toxaway Water Supply Study 2014, App H.

| | | | | | |
|---|---|---|---|---|---|
| **KEOWEE DAM** | | | | | |
| **Full Pond Elevation** | | | **Full Pond** | **800.00** | **Y** |
| **Critical Boat Access Levels** | | | **Public Access** | **790.00** | **Y** |
| **Critical Swimming Access Levels** | | | **Public Access** | **N/A** | **Y** |
| Greenville Water System | Witty Atkins WTP | Lake | Intake | 770.00 | Y |
| City of Seneca | Seneca City WTP | Lake | Intake | 775.00 | Y |
| Duke Energy Corporation | Oconee Nuclear Station | Lake | Intake | 794.60 | Y |
| **Hydro Operations** | | | **Hydro** | **775.00** | **Y** |

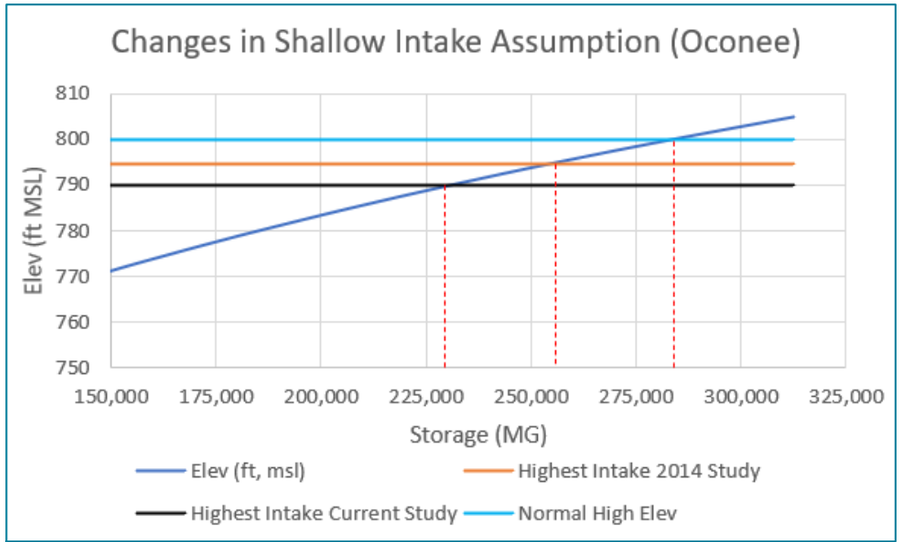
Keowee elevation 790 ft AMSL is based on the lowest boat ramp elevation of 787 ft AMSL plus 3 ft for boat access (provided by Duke Energy).

Keowee-Toxaway Water Supply Study 2014, App H.

**Table ES.2 Water Yield Evaluation – Critical Intake Constraint Summary**

| Reservoir | Projected Range of Water Yield Values (mgd) [Corresponding Water Use Projection Decade] Baseline | Blend2Dbv2 Operating Scenario |
|---|---|---|
| Licensee Reservoirs [1] | <69 [<Base Year] | >160 [>2066] |
| Hartwell | 24-38 [Base Year-2016] | <24 [<Base Year] |
| Russell | >10 [>2066] | >10 [>2066] |
| Thurmond | >53 [>2066] | >53 [>2066] |

Notes:
1 Combined Bad Creek, Jocassee, and Keowee Reservoirs, includes only a small net withdrawal from Bad Creek and Jocassee subbasins for agriculture/irrigation use projections.

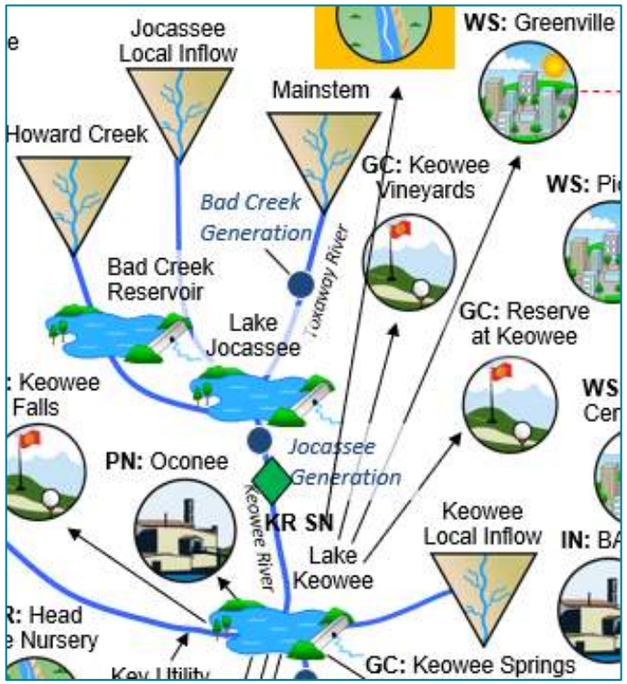



Oconee intake elevation has changed from 794.6 ft to 790 ft since this study

From 2014 Study: Safe Yield 69 - >160 MGD

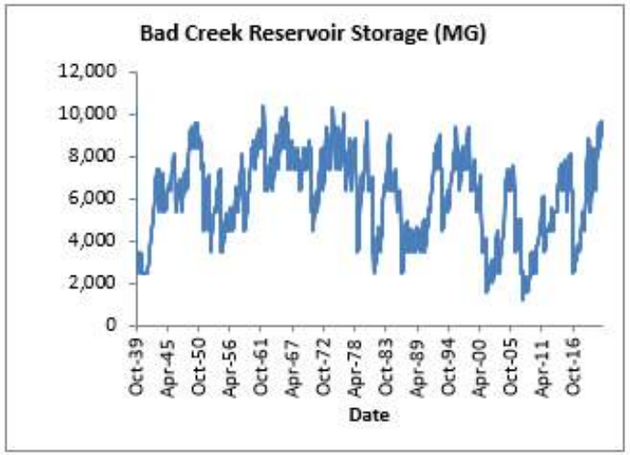
# Lake Keowee – Baseline

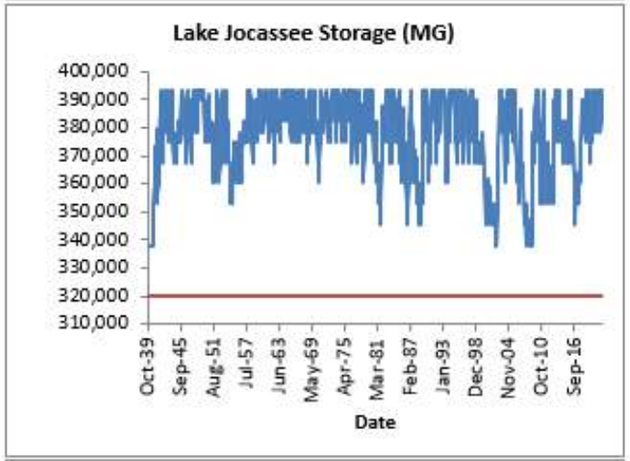
## (as a system with Bad Creek and Jocassee)

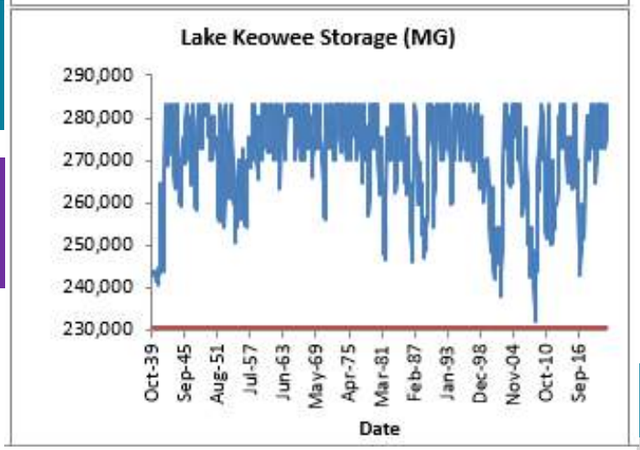



**Adjustments:**

No operational changes



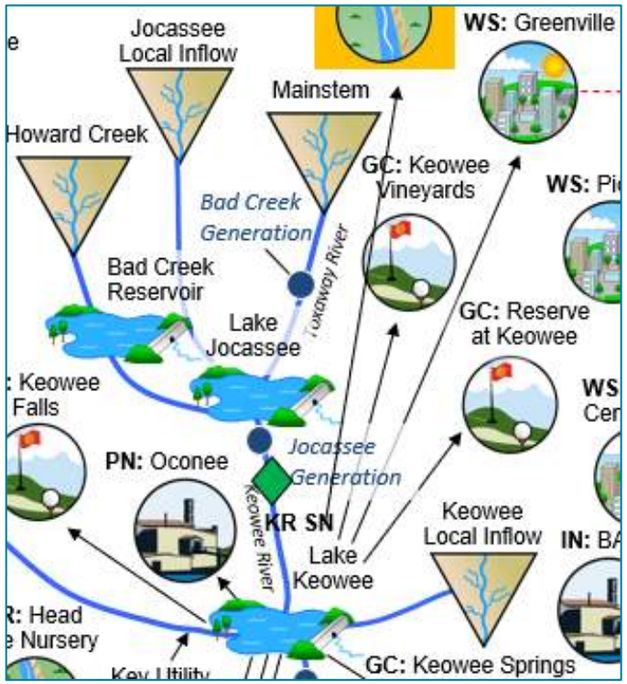



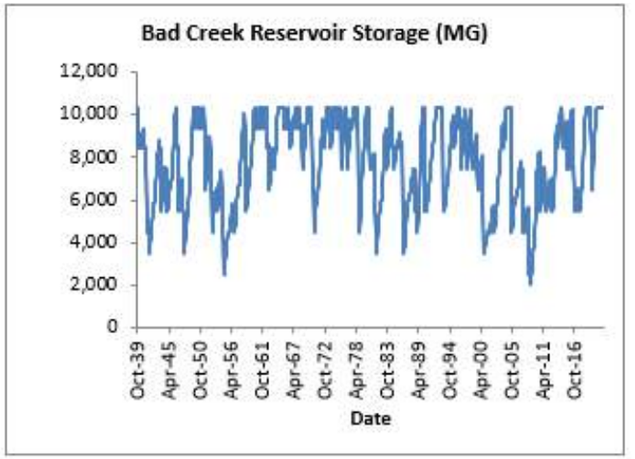



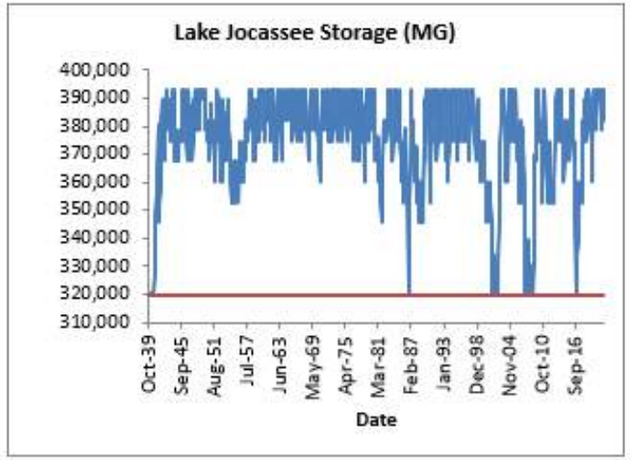

Keowee Safe Yield:
276 MGD

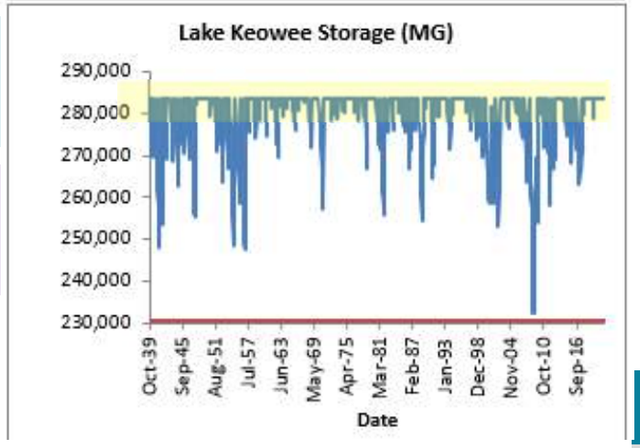
Similar results for
2070 HD and P&R

# Lake Keowee – Baseline/Rule Change
## (as a system with Bad Creek and Jocassee)




Keowee Safe Yield:
410 MGD

Similar results for
2070 HD and P&R

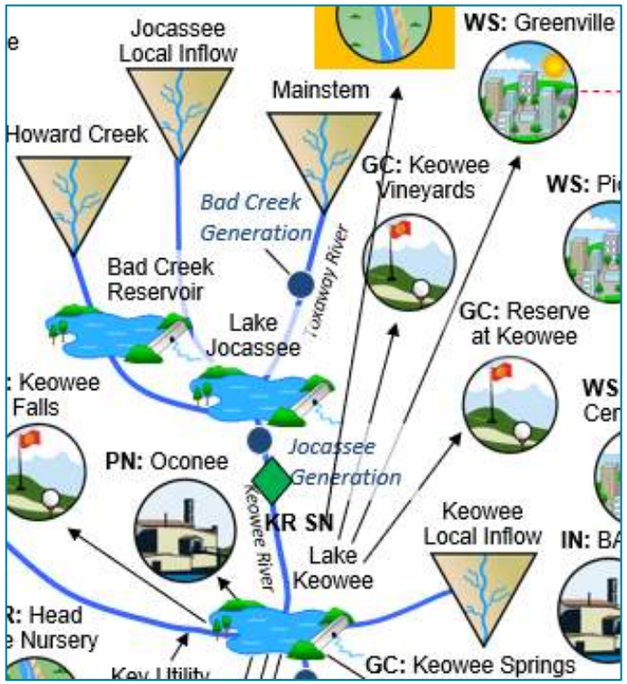
**Adjustments:**

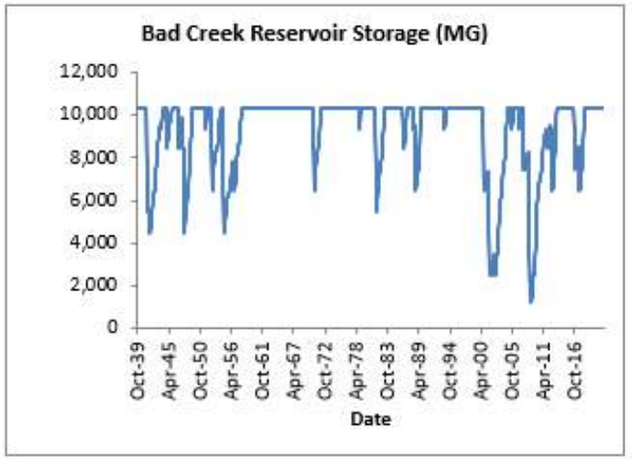
Bad Creek: No operating changes

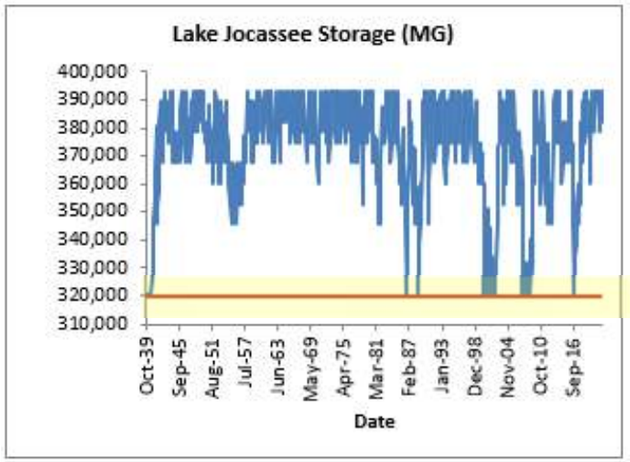
Jocassee: Allow low storage to reach dead pool

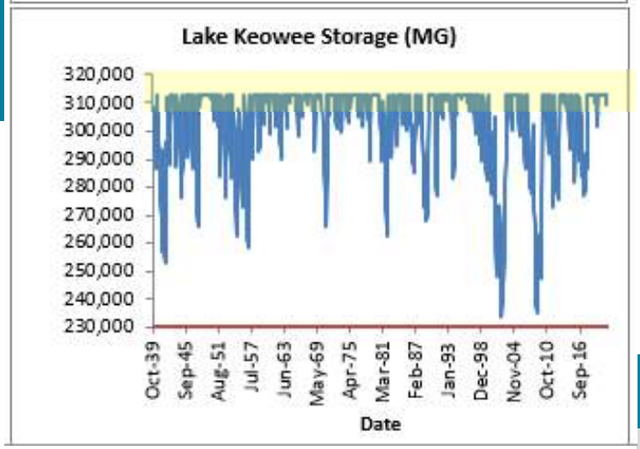
Keowee: Maintain downstream releases but suspend storage curves, restrict to max elevation of 800 ft.

# Lake Keowee – Baseline/Rule Change
## (as a system with Bad Creek and Jocassee)




Keowee Safe Yield:
484 MGD

**Adjustments:**

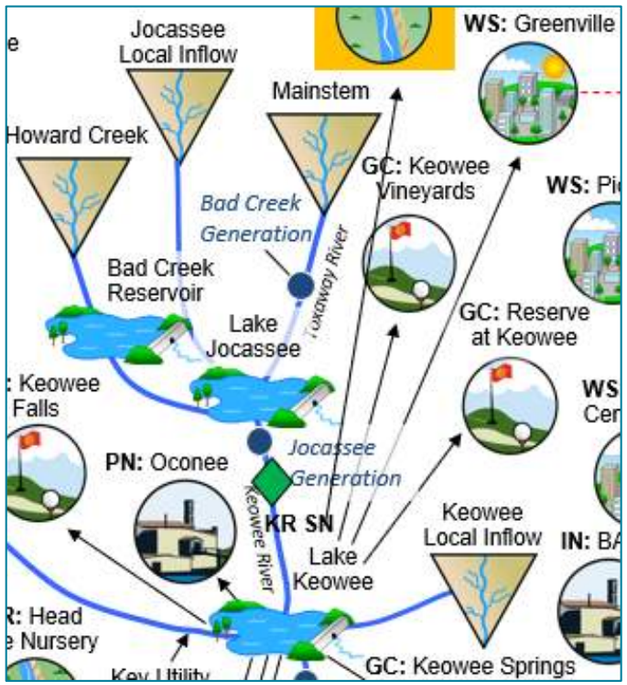
Bad Creek: No operating changes

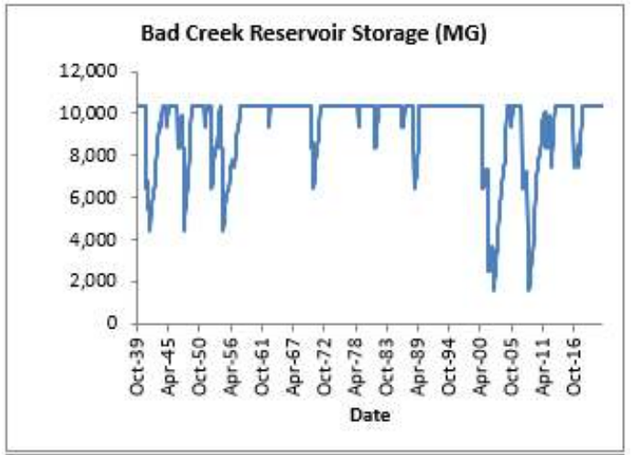
Jocassee: Allow low storage to reach dead pool

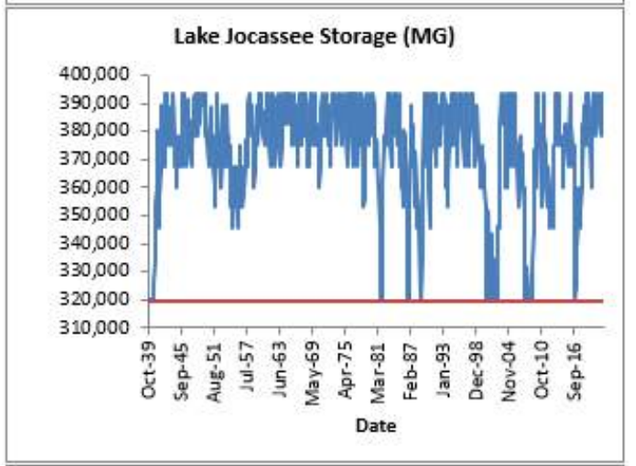
Keowee: Maintain downstream releases but suspend storage curves

# Lake Keowee – 2070 High Demand

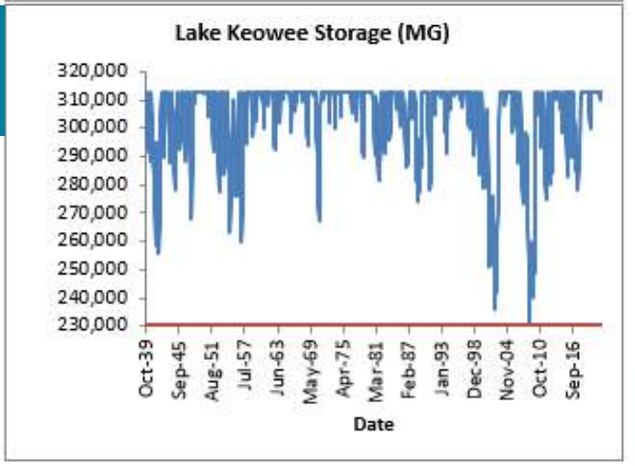
## (as a system with Bad Creek and Jocassee)




Keowee Safe Yield:
479 MGD




**Adjustments:**

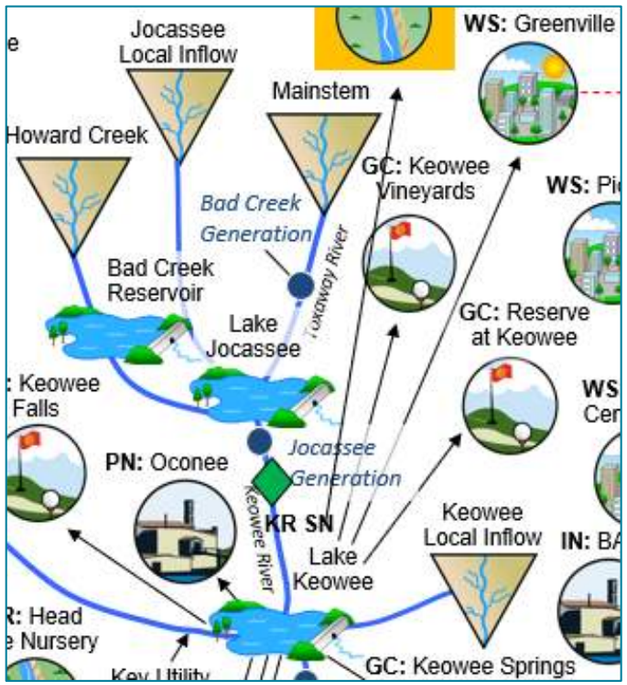
Bad Creek: No operating changes

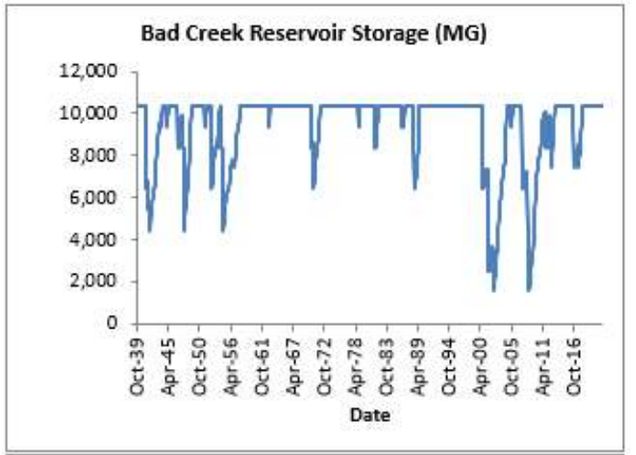
Jocassee: Allow low storage to reach dead pool

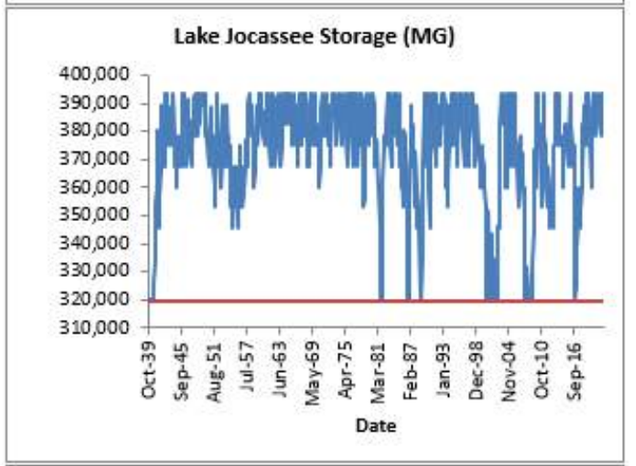
Keowee: Maintain downstream releases but suspend storage curves

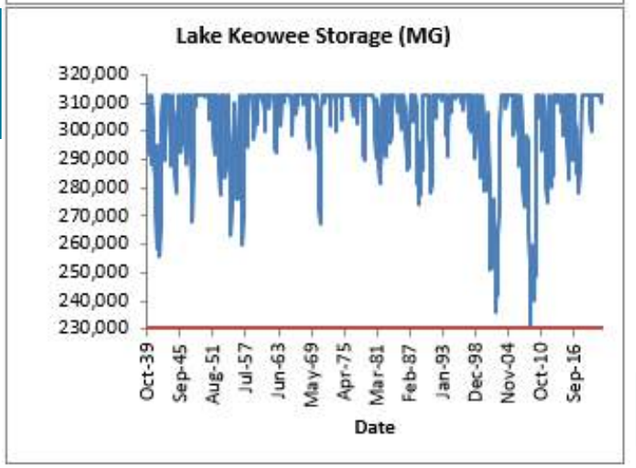
# Lake Keowee – P&R

## (as a system with Bad Creek and Jocassee)




Keowee Safe Yield:
~479 MGD

**Adjustments:**

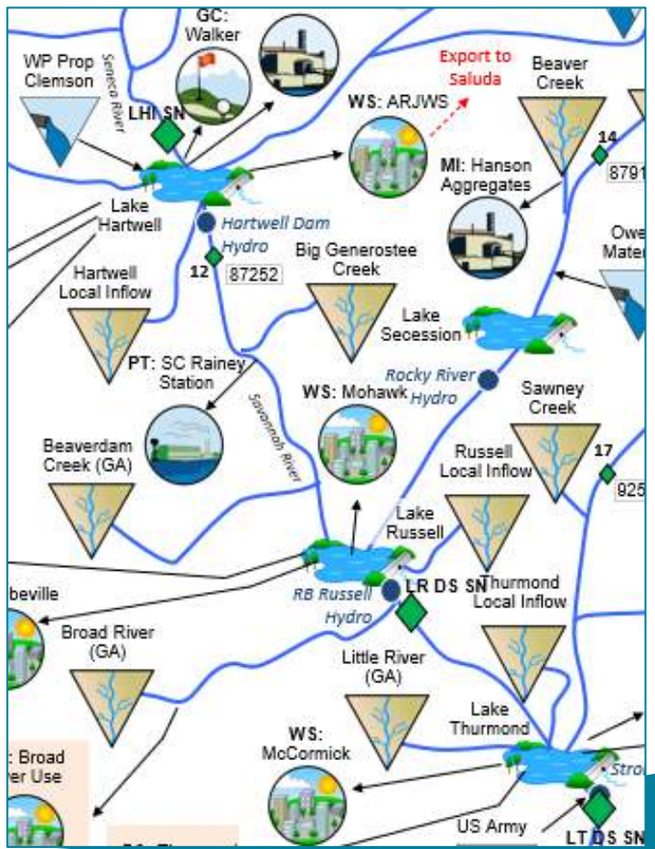
Bad Creek: No operating changes

Jocassee: Allow low storage to reach dead pool

Keowee: Maintain downstream releases but suspend storage curves

# Lower USACE Reservoirs

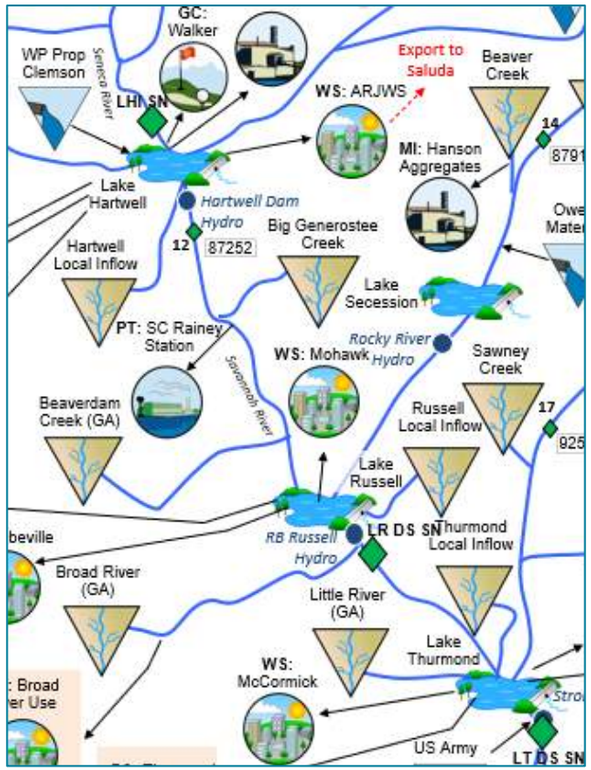
Lakes Hartwell, Russell, and Thurmond




- Evaluated Individually
- Intake: highest critical intake
- Upstream rules unchanged
- Downstream rules unchanged
- Guide curves for Reservoir being tested suspended but downstream releases maintained

# Lake Hartwell

## Intake based on Hydro Ops (625 ft)

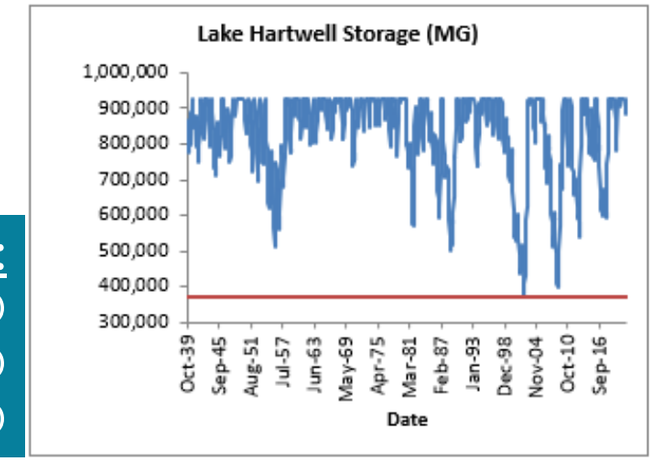


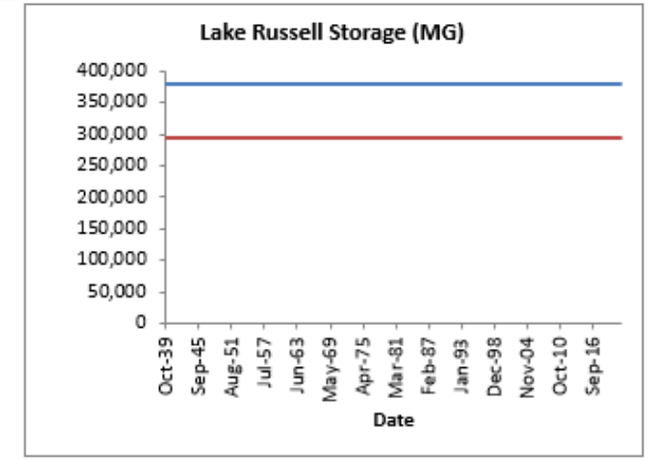

**Hartwell Safe Yield:**

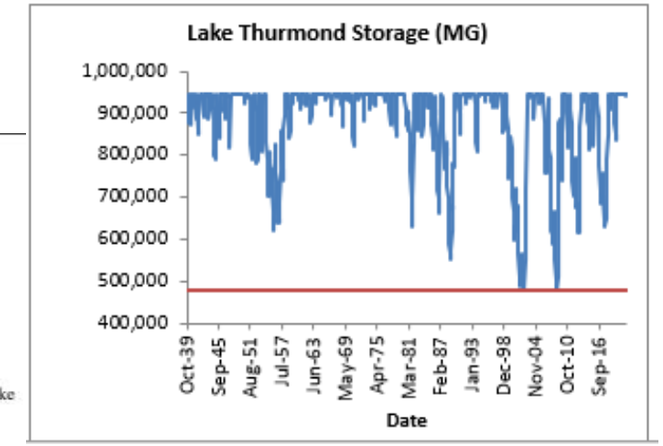
Baseline (Shown): 1060 MGD

2070 HD: 1002 MGD

Permitted and Registered: 899 MGD



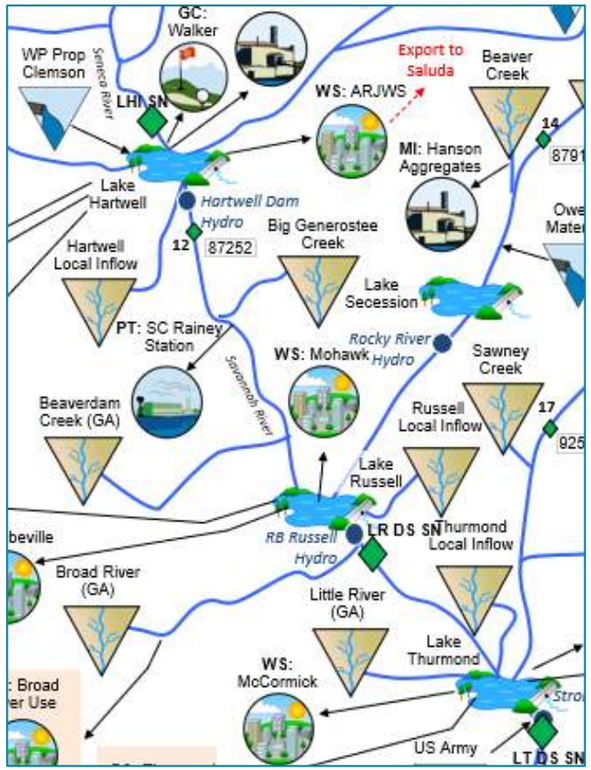




Keowee-Toxaway Water Supply Study 2014, App H.

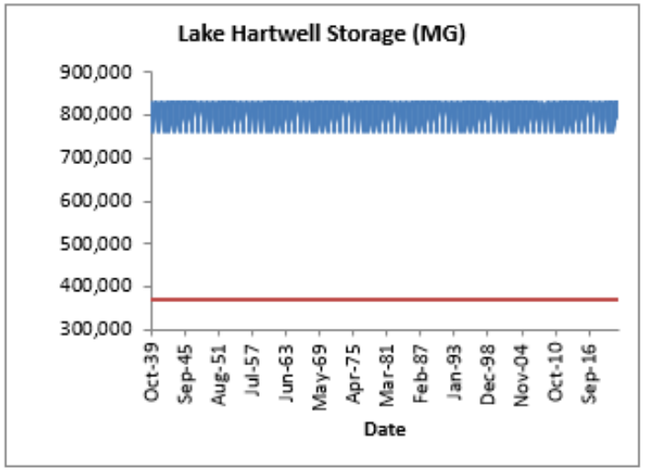
| | | | | | | |
|---|---|---|---|---|---|---|
| **HARTWELL DAM**[5] | | | | | | |
| **Full Pond Elevation** | | | **Full Pond** | **660.00** | **Y** | |
| **Critical Boat Access Levels**[6] | | | **Public Access** | **652.00** | **Y** | |
| **Critical Swimming Access Levels** | | | **Public Access** | **654.00** | **Y** | Level at which all USACE operated designated swimming areas are dry. |
| Anderson Regional Joint Water System | Hartwell Lake Filter Plant | Lake | Intake | 615.00 | Y | |
| City of Hartwell | Hartwell WTP | Lake | Intake | 612.00 | Y | |
| City of Lavonia | N/A | Lake | Intake | 636.00 | Y | |
| Milliken & Company | Pendleton Finishing Plant | Lake | Intake | 611.00 | Y | |
| J.P. Stevens | Westpoint Stevens Plant | Lake | Intake | 610.00 | Y | Facility demolished in 2008, intake no longer operational |
| Clemson University | Central Energy Facility | Lake | Intake | 638.00 | Y | |
| Clemson University Agriculture[3] | Musser Fruit Farm | Lake | Intake | 645.00 | Y | Can obtain water from City of Seneca if intake exposed, therefore not a critical intake |
| Clemson Golf Course[3] | Walker Golf Course | Lake | Intake | 633.00 | Y | |
| **Hydro Operations** | | | **Hydro** | **625.00** | **Y** | |

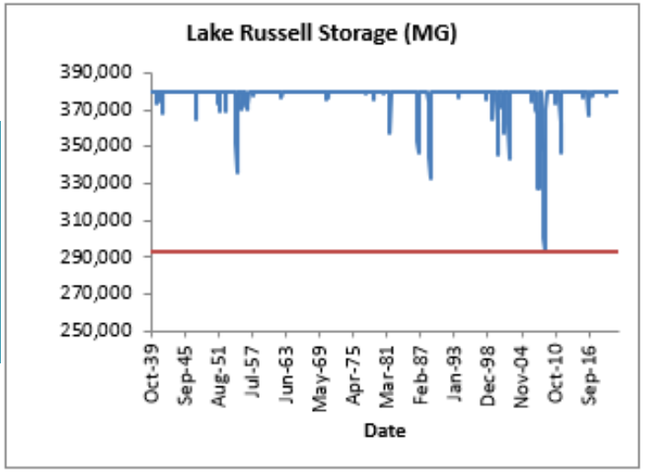
# Lake Russell

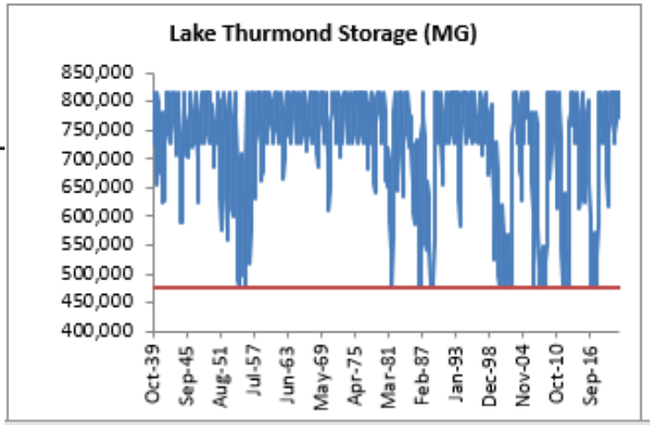
## Intake based on Hydro Ops (470 ft)




**Russell Safe Yield:**
Baseline (Shown): 1750 MGD
2070 HD: TBD
Permitted and Registered: TBD



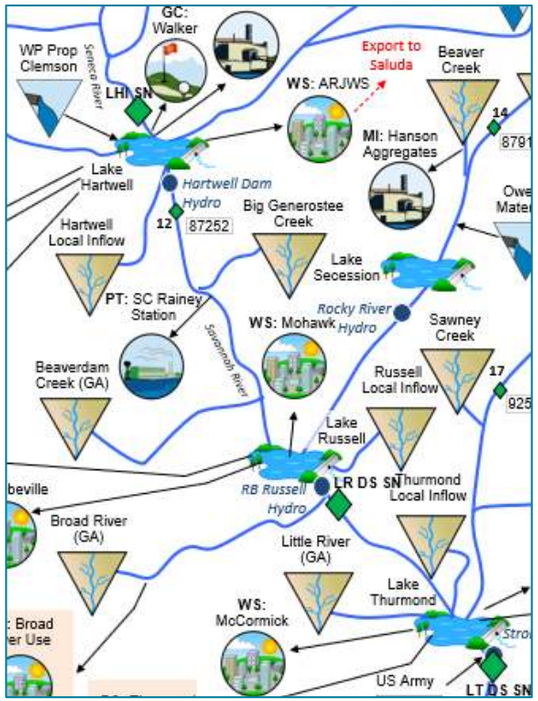



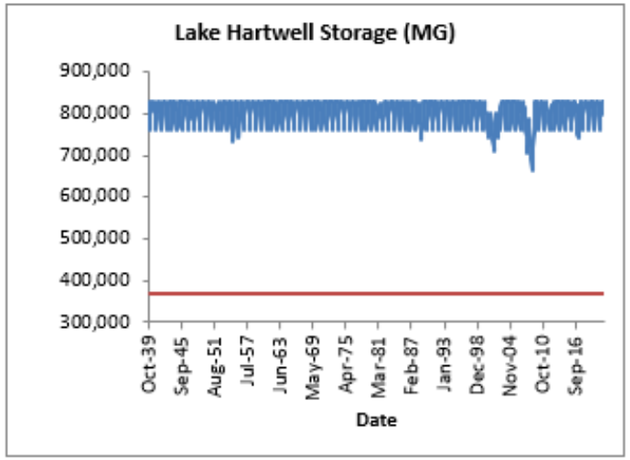

Keowee-Toxaway Water Supply Study 2014, App H.

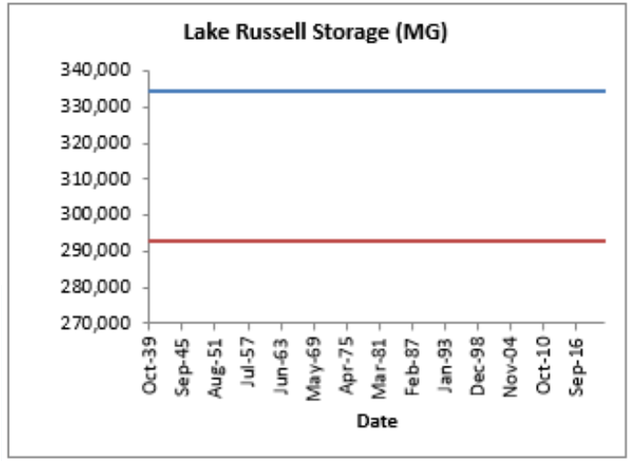
| | | | | | | |
|---|---|---|---|---|---|---|
| **RUSSELL DAM**[6] | | | | | | |
| **Full Pond Elevation** | | | **Full Pond** | **475.00** | **Y** | |
| **Critical Boat Access Levels**[6] | | | **Public Access** | **466.00** | **Y** | |
| **Critical Swimming Access Levels** | | | **Public Access** | **N/A** | **Y** | There are no USACE operated designated swimming areas on this reservoir. |
| City of Abbeville | Abbeville City WTP | Lake | Intake | 457.50 | Y | |
| City of Elberton | Elberton WTP | Lake | Intake | 465.00 | Y | |
| Town of Calhoun Falls[4] | Calhoun Falls WTP | Lake | Intake | 457.00 | Y | |
| Mohawk Industries, Inc. | Rocky River Plant | Lake | Intake | 464.75 | Y | Highest intake elevation of 3 |
| Santee Cooper | John Rainy Generating Station | Lake | Intake | 460.50 | Y | |
| RBR State Park[3] | RBR Golf Course | Lake | Intake | 468.80 | Y | |
| **Hydro Operations** | | | **Hydro** | **470.00** | **Y** | |

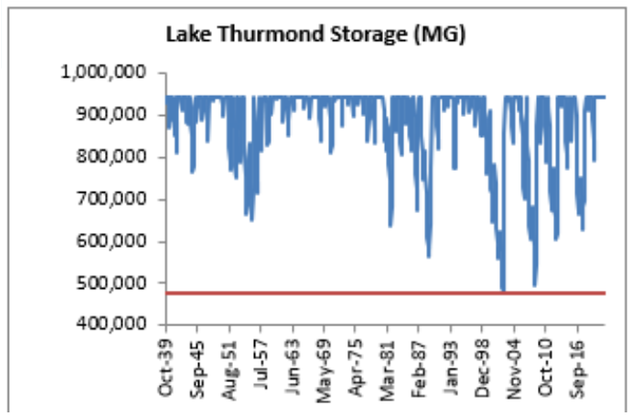
# Lake Thurmond

## Intake based on Hydro Ops (312 ft)




**Thurmond Safe Yield:**
Baseline (Shown): 186 MGD
2070 HD: TBD
Permitted and Registered: TBD

Keowee-Toxaway Water Supply Study 2014, App H.

| Lake System | Entity/Source Description | Facility | Lake/River | Description | Elevation (FT MSL) | Study Verified | Comments |
|---|---|---|---|---|---|---|---|
| **THURMOND DAM**[5] | | | | | | | |
| | **Full Pond Elevation** | | | **Full Pond** | **330.00** | **Y** | |
| | **Critical Boat Access Levels**[6] | | | **Public Access** | **320.00** | **Y** | |
| | **Critical Swimming Access Levels** | | | **Public Access** | **324.00** | **Y** | Level at which all USACE operated designated swimming areas are dry. |
| | McCormick Commission of Public Works | McCormick WTP | Lake | Intake | 304.00 | Y | |
| | Columbia County Water Utility | Clarks Hill WTP | Lake | Intake | 312.00 | Y | 2nd highest of 3 intakes[2] |
| | City of Lincolnton | James Allen Reed WTP | Lake | Intake | 311.00 | Y | Physical limit of pumping operation for intake structure[7] |
| | McDuffie County-City of Thomson | Big Creek | Lake | Intake | 312.00 | Y | 2nd highest of 3 intakes[2] |
| | City of Washinton[4] | Washington WTP | Lake | Intake | 307.00 | Y | |
| | Savannah Lakes POA[3] | Monticello Golf Course | Lake | Intake | 324.00 | Y | |
| | Savannah Lakes POA[3] | Tara Golf Course | Lake | Intake | 324.00 | Y | |
| | Hickory Knob State Park[3] | Hickory Knob Golf Course | Lake | Intake | 324.00 | Y | |
| | **Hydro Operations** | | | **Hydro** | **312.00** | **Y** | |

# Considerations and Next Steps

| Reservoir | Target Downstream Flow (conditional) |
|---|---|
| Hartwell | 2,000 cfs |
| Russell | 4,200 cfs |
| Thurmond | 3,100 – 4,500 cfs |

**Next Steps:**

- Confirm assumptions and methods with RBC
- Complete yield assessment for Russell and Thurmond (2070 HD and P&R)
- Compare average inflows and outflows (including spills)
- Experiment with alternative reservoir balancing (for yield estimates only)?