**Memorandum from the Office of the Inspector General**

January 7, 2010

Janet C. Herrin, WT 10D-K

FINAL REPORT – INSPECTION 2009-12652 – REVIEW OF TVA'S RESERVOIR OPERATIONS

Attached is the subject final report for your review. This report does not include any recommendations and is to be used for informational purposes only. Accordingly, no response is necessary.

Information contained in this report may be subject to public disclosure. Please advise us of any sensitive information in this report that you recommend be withheld.

If you have any questions, please contact Michael A. Driver, Project Manager, at (423) 785-4813 or Gregory C. Jaynes, Deputy Assistant Inspector General, Inspections, at (423) 785-4810. We appreciate the courtesy and cooperation received from your staff during this review.

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OIG File No. 2009-12652

Tennessee Valley Authority
Office of the Inspector General

*Inspection Report*

# REVIEW OF TVA'S RESERVOIR OPERATIONS

Inspection 2009-12652
January 7, 2010

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# TVA Office of the Inspector General

## Why the OIG Did This Review

Based upon questions posed to OIG personnel regarding TVA's criteria for the adjustment of tributary water levels, the OIG conducted a review of TVA's Reservoir Operations.

TVA is responsible for managing a range of programs in the Tennessee River Valley for the use, conservation, and development of the water resources related to the Tennessee River. In carrying out this mission, TVA operates a system of dams and reservoirs with associated facilities—its water control system. As directed by the TVA Act, TVA uses this system to manage the water resources of the Tennessee River for the purposes of navigation, flood control, power production and, consistent with those purposes, for a wide range of other public benefits.

The objectives of our review were to determine (1) whether criteria exist to balance the competing objectives of managing water in TVA reservoirs, (2) how those objectives compare to those of the U.S. Army Corps of Engineers, and (3) whether TVA was following its criteria. This report encompasses TVA-managed lakes, tributaries, and overall Reservoir Operations.

For more information, contact Robert E. Martin at (865) 633-7450 or remartin@tvaoig.gov; or Gregory C. Jaynes at (423) 785-4810 or gcjaynes@tvaoig.gov.

**January 2010**

# Inspection 2009-12652
# Review of TVA's Reservoir Operations

## What the OIG Found

Our review found TVA has Board-approved guidelines that were developed with public input in 2004.

We noted in discussion with two offices of the U.S. Army Corps of Engineers that they balance similar objectives and manage their reservoirs in a like manner as TVA's by balancing such goals as:

- Water supply.
- Water quality.
- Navigation.
- Hydroelectric power.
- Recreation.

The U.S. Army Corps of Engineers confirmed that, like TVA, they lower their reservoirs in the winter in order to provide flood control in anticipation of spring rains. Also, they raise reservoir levels in the summer months to provide recreational opportunities as well as meet other goals.

We performed testing based upon the approved TVA guidelines and found no issues. Specifically, we found that there were no issues related to the following summer criteria:

- Recreational Releases (releases water to enhance recreation opportunities).
- Chickamauga Flow (the required flow through Chickamauga Dam).
- Tributary Balancing (ensuring that no individual tributary is disproportionately affected when meeting river system minimum flow goals).

Lastly, we found there were no issues related to the following nonsummer criteria:

- Minimum Flow Commitments, which is measured in pulse commitment violations (a pulse represents a release of an agreed-upon amount of water, and a violation is an instance where TVA does not provide the pulse on time).
- Flood Storage Availability (flood storage is defined as the volume, or capacity, in a reservoir that is reserved for the storage of flood water, and anytime a tributary's headwater elevation exceeds the flood guide, it is in violation).

# BACKGROUND

Tennessee Valley Authority (TVA) is responsible for managing a range of programs in the Tennessee River Valley for the use, conservation, and development of the water resources related to the Tennessee River. In carrying out this mission, TVA operates a system of dams and reservoirs with associated facilities—its water control system. As directed by the TVA Act, TVA uses this system to manage the water resources of the Tennessee River for the purposes of navigation, flood control, power production and, consistent with those purposes, for a wide range of other public benefits. Based upon questions posed to Office of the Inspector General personnel regarding TVA's criteria for the adjustment of tributary water levels, we initiated a review of TVA's Reservoir Operations.

# OBJECTIVES, SCOPE, AND METHODOLOGY

The objectives of our review were to determine (1) whether criteria exist to balance the competing objectives of managing water in TVA reservoirs, (2) how those objectives compare to those of the U.S. Army Corps of Engineers, and (3) whether TVA followed its criteria. This report encompasses TVA-managed lakes, tributaries, and overall Reservoir Operations.

To achieve our objectives, we:

- Interviewed key TVA personnel to obtain an understanding of River Operations and the criteria that govern the reservoir system operations.
- Obtained supporting documentation to identify what criteria TVA has regarding the management of reservoirs.
- Reviewed and summarized key policies and procedures identified to gain program understanding.
- Identified performance measures being tracked by Reservoir Operations to assess guideline compliance. We tested:
  - All weekly Reservoir Operations Study Compliance Indicator[1] tracking sheets for June 1, 2009, through August 2, 2009, to determine adherence to the Reservoir Operations Study commitments for:
    - Recreational flow commitment.
    - Chickamauga flow commitment.
    - Tributary balancing.

[1] The Appendix provides an example of a Reservoir Operations Study Compliance Indicator tracking sheet that was used to document weekly performance.

- Documentation of Pulse[2] Violations and Flood Storage availability from October 1, 2008, through March 31, 2009, to determine adherence to established minimum flow commitments and flood storage availability goals.

This Inspection was conducted in accordance with the "Quality Standards for Inspections."

# FINDINGS

We found that TVA has developed and gained Board approval of the Reservoir Operations Study Preferred Alternative to guide the operations of the reservoirs. We noted in discussions with the U.S. Army Corps of Engineers that they balance similar objectives and operate their reservoirs in a similar fashion as TVA's. We also found that TVA complied with selected commitments required by the Reservoir Operations Study Preferred Alternative for the periods we reviewed.

## TVA HAS DEVELOPED CRITERIA THAT GOVERN RESERVOIR OPERATIONS

We found that TVA has defined criteria for the operation of the reservoir system. On May 19, 2004, the TVA Board approved a new reservoir operations policy, the Reservoir Operations Study Preferred Alternative, to be enacted on June 1, 2004. The policy was derived to provide increased opportunities for reservoir and tailwater recreation while meeting other operating objectives that include among others:

- Navigation
- Flood control
- Power production
- Water supply
- Water quality

The Reservoir Operations Study Preferred Alternative was developed and approved by the TVA Board after (1) receiving public input and (2) consideration of 25 alternatives. We also noted that TVA has used appropriate means to communicate its reservoir criteria and activities.

[2] A pulse is when TVA releases a specified amount of water at a specific time(s) to a tributary to meet minimum flows.

**Public Input**

In 1999, the Government Accountability Office released a report[3] providing information on, among other things, TVA's plans for Reservoir System operational changes. The report specifically recommended TVA, "provide for a formal and continuing communication process for the public and other stakeholders to actively participate in TVA's efforts to reexamine its policies impacting lake levels." To satisfy this, the Reservoir Operations Study solicited public input on how and what to change regarding the reservoir policy. TVA stated in the published Reservoir Operations Study that in the course of the study TVA:

- Mailed 60,000 letters to stakeholders in the Tennessee Valley.
- Received more than 6,000 individual comments.
- Received 4,200 form letters.
- Was given a petition with more than 5,400 signatures.
- Surveyed 3,600 residents at home.

The Reservoir Operations Study also conducted workshops to obtain public input. From these workshops, TVA found that the public's top priorities were:

- Recreation (34 percent of respondents).
- Environment (21.5 percent).
- Flood Control (21.5 percent).

Some concerns were identified through the public input process and noted in the Reservoir Operations Study. Specifically, it was noted that the public wanted consideration given to (1) holding reservoir levels stable, (2) delaying the date in which summer water levels are lowered, (3) raising the water levels earlier to increase fish spawning, and (4) increasing the amount of water releases by various dams to improve fishing conditions. In addition to the public input, the Reservoir Operations Study stated that the U.S. Army Corps of Engineers as well as the U.S. Fish and Wildlife Service participated in the development of the new guidelines.

**Policy Alternatives**

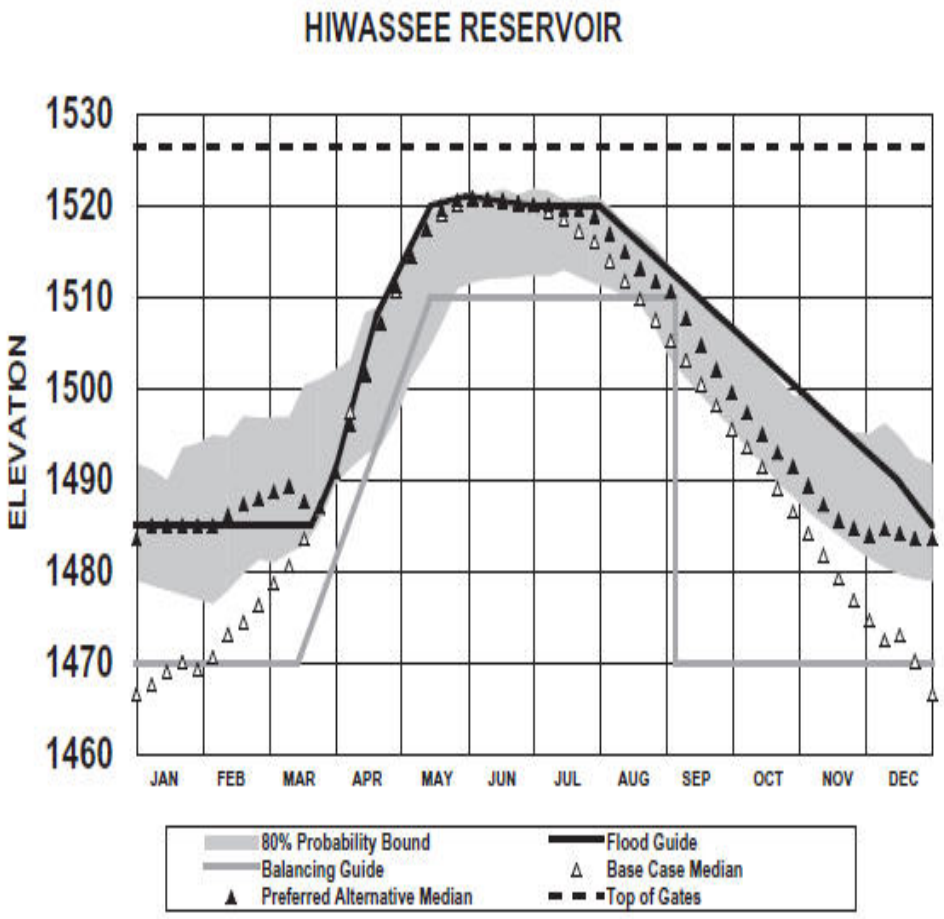
TVA developed 25 policy alternatives and performed computer simulations on each to measure and evaluate (1) reservoir elevations, (2) streamflow conditions, (3) water availability during varying hydrological conditions, and (4) for some alternatives, the cost of power and power availability. In the end, TVA considered in-depth eight policy alternatives which included the alternative to not change their current operation. The Reservoir Operations Study Preferred Alternative was ultimately decided upon. This alternative operates the reservoir

[3] 1999 Government Accountability Office report, "TENNESSEE VALLEY AUTHORITY: Future Study of Lake Levels Should Involve Public and Consider Cost and Benefits."

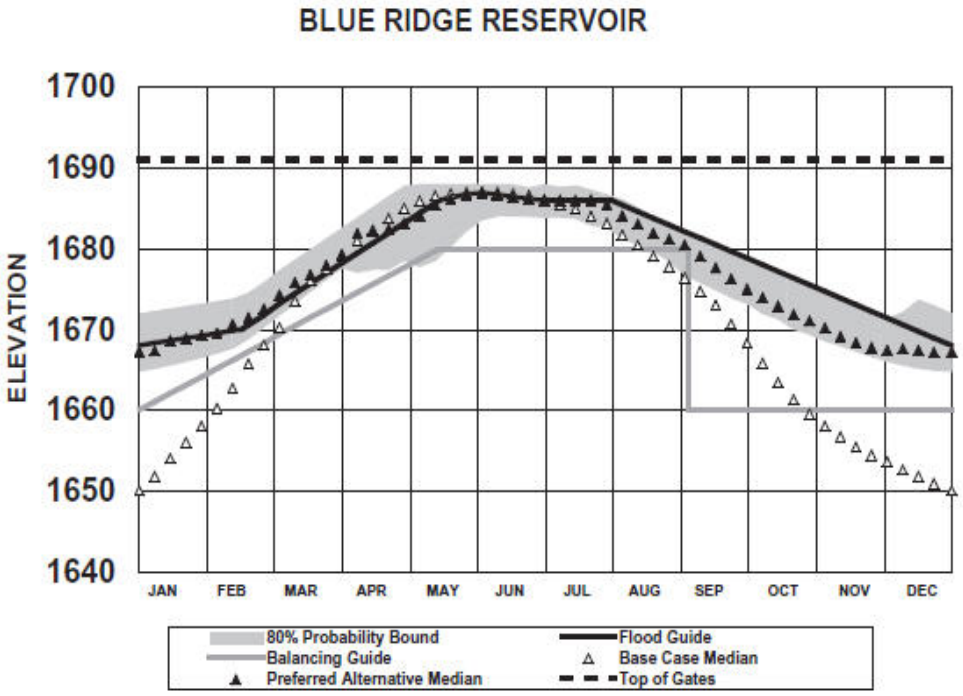
system to provide increased opportunities for reservoir and tailwater recreation while meeting other operating objectives including navigation, flood control, power production, water supply, and water quality.

While the Reservoir Operations Study Preferred Alternative provides opportunities for increased recreation by increasing some of the summer and winter reservoir elevations, it decreases the flood storage availability. As shown in the following graphs of TVA's operating guide curves for both the Hiwassee Tributary and the Blue Ridge Tributary, the summer and winter elevations were increased under the Reservoir Operations Study Preferred Alternative. Specifically, the white triangles in the graphs represent the base case scenario or what was in effect previous to the new policy, and the black triangles represent the Reservoir Operations Study Preferred Alternative operating guidelines.

**Graph 1: Hiwassee Reservoir Elevation Guide by Month**



**Graph 2: Blue Ridge Reservoir Elevation Guide by Month**




Additionally, while TVA was performing its Reservoir Operations Study, The University of Tennessee Center for Business and Economic Research released a May 2003 study[4] of TVA's lake level management in East Tennessee. In this study, the report concluded the following:

> Based on the survey of recreators it is estimated that $5.4 million in new spending would take place within the multi-county lake region on the part of nonresidents should drawdowns be delayed to the end of September. Inclusive of the ripple effects of the multiplier, this initial spending would yield $2.35 million in new income for area residents and 124 annual full-time equivalent jobs (or 744 jobs for the two-month period of August and September). Increased recreation activity by nonresidents would boost Tennessee (as opposed to only lake-region) income by $1.9 million and add 100 annual jobs (or 600 jobs for August and September).

As stated above, this independent study concluded that delaying the drawdown of lakes would result in economic benefits for the region. Our review found that the subsequent Reservoir Operations Study Preferred Alternative did result in higher reservoir elevations throughout the year.

[4] The University of Tennessee Center for Business and Economic Research: TVA Lake Level Management Study, May 2003.

### Communication of Operations

In order to communicate TVA's criteria for, and overall operations of, its Reservoir System, TVA has employed various means to inform the public of its activities. Such communications have included:

- Press releases.
- River Neighbors e-newsletters distributed via e-mail as well as regular mail for those without Internet access.
- A communications tour providing information to local newspapers and lake interest groups during public forums.
- A comprehensive Web site detailing the operations of each reservoir.
- Talking points drafted to answer questions from those who call TVA with questions.

To determine the efficacy of TVA communications practices, we interviewed TVA's Senior Vice President of Communications and reviewed the various means of communication. While being relatively new to TVA, TVA's Senior Vice President of Communications' background in various industries gives him unique perspective to comment on TVA's communications efforts related to reservoir operations. He noted that, based on his experience at other government organizations, TVA's communications practices in this area were reasonable. As a result of our consideration of the various means of communication TVA employs and discussions with TVA's Senior Vice President of Communications, we believe TVA makes a reasonable effort to inform the public about its reservoir operations.

## U.S. ARMY CORPS OF ENGINEERS BALANCES SIMILAR OBJECTIVES AND OPERATES SIMILARLY TO TVA

To obtain a comparison to other entities that control reservoir systems, we contacted the U.S. Army Corps of Engineers' Nashville office as well as the Mobile, Alabama, office which has responsibility for selected North Georgia reservoirs. In our discussions, we were informed that the U.S. Army Corps of Engineers operates under similar purposes and objectives as TVA's. They operate their reservoirs in a manner so as to balance such priorities as (1) water supply, (2) water quality, (3) navigation, (4) hydroelectric power, and (5) recreation.

We were also informed that dam safety and flood control were also goals of the overall operation. Both U.S. Army Corps of Engineers' offices informed us that each project[5] has a guide curve, and the water in the particular projects is (1) drawn down in the winter to allow for flood storage in anticipation of spring rains and (2) raised in the summer to provide for additional recreation. This is similar to the manner in which TVA manages its reservoirs.

[5] River Operations uses project to refer to a tributary or mainstem reservoir.

We also noted in our discussion with the U.S. Army Corps of Engineers and TVA that the topography of reservoirs are different from one another. Therefore, the differences in the drawdown for lakes would be different. For example, a five-foot drawdown on a shallow, broad surface lake would be different than a deep, narrow surface lake. Because of this, the drawdown amounts, in terms of elevation, will be different for each reservoir. U.S. Army Corps of Engineers' officials in Nashville said they were in daily contact with TVA and were complimentary of TVA operations.

## TVA COMPLIED WITH KEY ELEMENTS OF THE RESERVOIR OPERATIONS STUDY PREFERRED ALTERNATIVE

Our review found that TVA was in compliance with key elements of the TVA Board-approved Reservoir Operations Study Preferred Alternative. Specifically, during the:

- Summer months, those key elements are recreation flow commitments, Chickamauga flow commitments, and tributary balancing ratios.
- Nonsummer months, those key elements are water releases to meet minimum flow commitments (i.e., which is measured by pulse commitment violations) and flood storage availability.

### Recreation Flow Commitment

As a part of the Reservoir Operations Study Preferred Alternative, TVA has committed to providing recreational releases of water at the Apalachia, Norris, Ocoee No. 1, and Watuaga/Wilbur reservoirs in addition to other releases they work to achieve. Based on our test results, we conclude that for the period we reviewed, TVA met the new recreational flow commitments. Specifically, we found from June 1, 2009, to August 2, 2009, TVA met 152 of the 153 required recreational flow commitments for the four reservoirs.

One commitment for the Norris Reservoir was not met due to a forced outage. We noted that the problem was resolved within 25 minutes from the designated start of the scheduled commitment, and the normal flow commitment was fulfilled for 4 hours after problem resolution. However, because the turbine was not activated within the {REDACTED} window of the commitment schedule, the commitment was not counted as being met.

### Chickamauga Flow Commitment

The Chickamauga flow commitment is designed to ensure there is adequate flow across the entire TVA river system. To do so, TVA has set certain guidelines for flows going through the Chickamauga Reservoir. Depending on hydrological conditions at the time, the targeted average flow may be adjusted; therefore, it is possible to have multiple targets within the same week. We reviewed the Chickamauga flows from June 1, 2009, to August 2, 2009, to assess whether the targeted average flow goal:

- Was met within {REDACTED} when the sum of the storage in the ten tributaries was above the minimum operations guide parameters; or
- Was equal to 13,000 cubic feet per second {REDACTED} when the sum of the storage in the ten tributaries was below the minimum operations guide parameters.

As shown in Table 1 below, all targets were met except those where the system was recovering to flood guide.

**Table 1 – Chickamauga Flow**

| Week in FY 2009 | TVA Targeted Average Weekly Flow in Cubic Feet Per Second | Average Weekly Flow Achieved | Result |
|---|---|---|---|
| 06/07 | 14,000 | 28,757 | Above Target (Recovering to flood guide) |
| 06/14 | 15,000 | 28,073 | Above Target (Recovering to flood guide) |
| 06/21 | 16,000 | 28,518 | Above Target (Recovering to flood guide) |
| 06/28 | 17,000 | 32,076 | Above Target (Recovering to flood guide) |
| 07/05 | 19,000 | 19,211 | On Target |
| 07/06 - 07/11<br><br>07/12 | 21,000<br><br>13,000 | 20,759<br><br>13,148 | On Target<br><br>On Target |
| 07/13- 07/17<br><br>07/18 - 07/19 | 23,000<br><br>13,000 | 23,071<br><br>13,090 | On Target<br><br>On Target |
| 7/20 - 7/21 &<br>7/23 - 7/26<br><br>7/22 | 13,000<br><br>25,000 | 13,050<br><br>25,032 | On Target<br><br>On Target |
| 7/27-7/31<br><br>8/1-8/2 | 25,000<br><br>29,000 | 25,270<br><br>29,279 | On Target<br><br>On Target |

In summary, our testing found both during normal target conditions and modified target conditions, all targets were met except those where the system was recovering to flood guide due to the hydrological conditions. Specifically, we noted:

- Four weeks above target where tributaries were recovering to flood guide due to excess rain.
- One week where the tributary system went above the system minimum operating guide and the target was revised to 25,000 cubic feet per second {REDACTED} in accordance with established processes.
- Three weeks where the tributary storage system fell below the minimum operations guide and the target was revised to 13,000 cubic feet per second {REDACTED} in accordance with established processes.

Based on our test results, we conclude that TVA met the Chickamauga flow requirements of the Reservoir Operations Study Preferred Alternative for the period we reviewed.

**Tributary Balancing**

As a part of the Reservoir Operations Study Preferred Alternative, TVA has committed to keep ten upstream tributaries[6] balanced in relation to one another to ensure that no particular reservoir is adversely affected when meeting downstream flow requirements. To be considered balanced, the ratios must be +/- 0.05 of the ratio average on Sunday nights when the measurements are tested.

We tested nine weeks of balancing ratios to determine whether TVA was meeting its commitment and found the reservoirs were balanced for all nine weeks tested. We noted that in four of the nine weeks reviewed, certain reservoirs were excluded from the balancing calculation primarily due to heavy rains received in the general area of that reservoir which pushed the headwater elevation to the flood guide level. Our review of documentation and interviews with the Reservoir Operations staff found they have some leeway to the balancing when certain hydrological conditions such as heavy rain or drought exist. There was also one week where a reservoir was excluded due to a recreational commitment made by the reservoir team.

Based on our test results, we conclude that TVA fulfilled the tributary balancing requirement of the Reservoir Operations Study Preferred Alternative for the period we reviewed.

[6] These tributaries are South Holston, Watauga, Cherokee, Douglas, Fontana, Norris, Chatuge, Nottely, Hiwassee, and Blue Ridge.

### Minimum Flow Commitments

The minimum flow commitments are designed to provide a specified amount of water flowing through the various reservoirs. The minimum flow commitment is measured by the number of pulse commitment violations. A pulse is where TVA releases a specified amount of water at a specific time(s) to a tributary to meet minimum flows. A pulse violation is where TVA did not meet the time agreement or the target of amount of water released.

To test whether TVA met minimum flow commitments, we reviewed the number of pulse violations from October 1, 2008, to March 31, 2009. We visually inspected the log books for each of these months and verified the number of violations. We noted no deviations from the percentage goal to be met, as shown in Table 2. Therefore, based on our test results, we conclude that TVA met minimum flow requirements for the period we reviewed.

### Table 2 – Pulse Violations

| Month | Number of Site Days (29 Sites) | Number of Violations | Percentage Met | Goal |
|---|---|---|---|---|
| October | 899 | 9 | 99.0% | 99.0% |
| November | 870 | 4 | 99.54% | 99.0% |
| December | 899 | 3 | 99.67% | 99.0% |
| January | 899 | 0 | 100% | 99.0% |
| February | 812 | 1 | 99.88% | 99.0% |
| March | 899 | 3 | 99.67% | 99.0% |

### Flood Storage Availability

TVA must retain a certain amount of flood storage, which is defined as the volume or capacity, in a reservoir that is reserved for the storage of floodwater. Anytime a tributary's headwater elevation exceeds the flood guide by more than one foot, it is in violation.

To test whether TVA met flood storage availability requirements, we reviewed the number of violations from October 1, 2008, to March 31, 2009, in relationship to the goal for TVA's 12 projects (i.e., Chatuge, Nottely, Blue Ridge, Norris, Douglas, Fontana, South Holston, Watauga, Tims Ford, Cherokee, Hiwassee, and tributary system taken as a whole). We found TVA complied with its monthly goals as to the cumulative percentage of time the projects were required to be within flood zone requirements, as shown in Table 3. Therefore, based on our test results, we conclude that TVA met its goal of keeping the tributaries within the boundaries of their flood guides for the period we reviewed.

## Table 3 – Flood Storage Availability

| Month | Number of Project Days | Cumulative Project Days | Days Above Flood Storage | Cumulative Days Above Flood Storage | Goal Percentage (TVA Target) | Actual Cumulative Percentage Within Flood Zone |
|---|---|---|---|---|---|---|
| October | 372 | 372 | 0 | 0 | 91.0% | 100.00% |
| November | 360 | 732 | 4 | 4 | 86.0% | 99.5% |
| December | 372 | 1104 | 125 | 129 | 81.0% | 88.3% |
| January | 372 | 1476 | 201 | 330 | 71.0% | 77.6% |
| February | 336 | 1812 | 102 | 432 | 64.0% | 76.2% |
| March | 372 | 2184 | 137 | 669 | 59.0% | 69.4% |

# Reservoir Operations Study Compliance Indicator

ROS COMPLIANCE INDICATOR
RO (OPERATIONS) SUB-COMPONENT TRACKING SHEET
FOR THE WEEK ENDING 6/7/09
Prepared by DAH
Verified by _____

**Tailwater Recreation Commitment**

| Dam | # ROS Commitments | # of Commitments this week in 2005 * | Actual # Met |
|---|---|---|---|
| Apalachia | 7 | | 7 |
| Norris | 2 | | 2 |
| Watauga/Wilbur | 6 | | 6 |
| Ocoee #1 | 2 | | 2 |

*If different from original ROS commitments, explain why:
Kids fishing day conducted below NOH on 6/6 resulted in minimum flows until 1200.

**Chickamauga Flow Commitment** (applicable from June 1 through Labor Day)

| | |
|---|---|
| Volume of water in storage | 8.28 million acre-ft |
| System MOG | 7.94 million acre-ft |
| Weekly average flow target | 14000 cfs |
| Actual weekly average flow | 28757 cfs * |

*If higher or lower than weekly average flow target, explain why:
CHH weekly flow due to tributary reservoirs recovering to flood guide.

**Uniformity of Tributary Balancing Ratio** (applicable from June 1 through Labor Day)

| Reservoir | Ratio | Balanced * (Yes or No) | Balanced*** | Balanced*** | |
|---|---|---|---|---|---|
| South Holston | 1.04 | Y | | | |
| Watauga | 1.04 | Y | | | |
| Cherokee | 1.04 | Y | | | |
| Douglas | 1.05 | Y | | | |
| Fontana | 1.07 | Y | | | #met/ |
| Norris | 1.02 | Y | | | |
| #included= | | | | | |
| Chatuge | 1.09 | Y | | | 10/10 |
| Nottely | 1.06 | Y | | | |
| Hiwassee | 1.06 | Y | | | |
| Blue Ridge | 1.08 | Y | | | |
| Average | 1.06 ** | | *** | *** | |

*** See instructions for the use of this portion of the tracking sheet.
* A reservoir is balanced if the ratio is within +/- .05 of the average.
** If a reservoir is not included in the average, please list the one(s) not included and why.