Attachment 4 to Enclosure 1 is to be withheld from public disclosure under 10 CFR 2.390. When separated from this attachment, this letter is decontrolled.

TVA

Tennessee Valley Authority, 1101 Market Street, Chattanooga, Tennessee 37402

August 10, 2012

10 CFR 50.90
10 CFR 2.390(d)(1)

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Sequoyah Nuclear Plant, Units 1 and 2
NRC Docket Nos. 50-327 and 50-328
Facility License Nos. DPR-77 and DPR-79

Subject: **Application to Revise Sequoyah Nuclear Plant Units 1 and 2 Updated Final Safety Analysis Report Regarding Changes to Hydrologic Analysis, (SQN-TS-12-02)**

References:

1. Tennessee Valley Authority (TVA) Submittal to NRC Document Control Desk, "Application to Revise Watts Bar Nuclear Plant Unit 1 Updated Final Safety Analysis Report Regarding Changes to Hydrologic Analysis, TAC No. ME8200 (WBN-UFSAR-12-01)," dated July 19, 2012

2. Tennessee Valley Authority (TVA) Submittal to NRC Document Control Desk, "Commitments Related to Updated Hydrologic Analysis Results for Sequoyah Nuclear Plant, Units 1 and 2, and Watts Bar Nuclear Plant, Unit 1," dated June 13, 2012 (ADAMS Accession No. ML12171A053)

3. NRC Meeting Summary, "Summary of March 29, 2012, Pre-Application Meeting with Tennessee Valley Authority on Changing the Licensing Basis for Hydrologic Engineering (TAC No. ME8200)," dated April 11, 2012 (ADAMS Accession No. ML12097A306)

In accordance with the provisions of 10 CFR 50.90, "Application for amendment of license, construction permit, or early site permit," the Tennessee Valley Authority (TVA) is submitting a request for an amendment to Facility Operating License Nos. DPR-77 and DPR-79 for Sequoyah Nuclear Plant (SQN), Units 1 and 2.

This license amendment request seeks approval to revise the SQN Units 1 and 2 Updated Final Safety Analysis Report (UFSAR) to adopt a revised hydrologic analysis for the SQN Units 1 and 2 site. These changes to the SQN Units 1 and 2 UFSAR are proposed to be consistent with the latest approved calculations. The proposed technical changes to the SQN Units 1 and 2 UFSAR include changes, in part, currently under review by the NRC in the Watts Bar Nuclear Plant (WBN) Unit 1 UFSAR submitted in the Reference 1 letter.

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The proposed changes in the updated hydrologic analysis include updated input information, and updates to methodology which includes use of the U.S. Army Corps of Engineers (USACE) Hydrologic Modeling System (HEC-HMS) and River Analysis System (HEC-RAS) software. As a result of these proposed changes, the design basis flood (DBF) elevations at the SQN Units 1 and 2 site are revised.

These changes are determined to impact existing flooding protection requirements for several SQN Units 1 and 2 safety-related systems, structures, or components, which include the Spent Fuel Pit Cooling Pump Motors and applicable equipment required for flood mode operation located in the Diesel Generator Building. To restore margin for the Spent Fuel Pit Cooling Pump Motors, the Spent Fuel Pit Cooling Pump Enclosure caps are required to be in place in the event of a Stage I flood warning as a compensatory measure. For the Diesel Generator Building, staged sandbags to be constructed into a berm at any time prior to or during the event of a Stage I flood warning has been established as a compensatory measure.

As committed to in the Reference 2 letter, TVA will implement a documentation change to require the Spent Fuel Pit Cooling Pump Enclosure caps as a permanent plant feature for flooding protection, and will install permanent plant modifications to provide adequate flooding protection with respect to the DBF level for the Diesel Generator Building, by March 31, 2013.

Enclosure 1 provides a description, technical evaluation, regulatory evaluation and environmental consideration of the proposed technical changes. TVA is requesting NRC review and approval of the technical changes to the SQN Units 1 and 2 UFSAR as described in Enclosure 1 to incorporate the cumulative effects that have occurred in the SQN Units 1 and 2 hydrologic analyses since issuance of the Operating License. Specific technical changes are proposed in SQN Units 1 and 2 UFSAR Sections 2.4, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 2.4.11, 2.4.14, and Appendix 2.4A. Additional editorial changes are shown for SQN Units 1 and 2 UFSAR Section 2.4 and do not require NRC review and approval.

Attachment 1 to Enclosure 1 provides the existing SQN Units 1 and 2 UFSAR text marked up to show the proposed changes.

Attachment 2 to Enclosure 1 provides the proposed replacement SQN Units 1 and 2 UFSAR Section 2.4 tables.

Attachment 3 to Enclosure 1 provides the proposed replacement SQN Units 1 and 2 UFSAR Section 2.4 figures suitable for public disclosure.

Attachment 4 to Enclosure 1 provides the proposed replacement SQN Units 1 and 2 UFSAR Section 2.4 figures that contain security-related information identified by the designation "Security-Related Information - Withhold Under 10 CFR 2.390." TVA hereby requests this information be withheld from public disclosure in accordance with the provisions of 10 CFR 2.390(d)(1).

Enclosure 2 provides responses to the issues identified by the NRC Staff in the Reference 3 letter regarding the pre-application meeting held between TVA and the NRC Staff on March 29, 2012. This meeting involved the License Amendment Request that was under

development for proposed changes to the WBN Unit 1 UFSAR submitted in the Reference 1 letter. The description, technical evaluation, regulatory evaluation and environmental consideration of the proposed technical changes provided in Enclosure 1 address these issues where applicable to SQN Units 1 and 2.

TVA requests that the NRC approve this amendment by August 10, 2013.

TVA has determined that there are no significant hazards considerations associated with the proposed changes and that the changes qualify for a categorical exclusion from environmental review pursuant to the provisions of 10 CFR 51.22(c)(9).

The SQN Plant Operations Review Committee and the SQN Nuclear Safety Review Board have reviewed the proposed changes and determined that operation of SQN in accordance with the proposed changes will not endanger the health and safety of the public.

Additionally, in accordance with 10 CFR 50.91(b)(1), TVA is sending a copy of this letter and the enclosure to the Tennessee Department of Environment and Conservation.

There are no new regulatory commitments in this letter. Please address any questions regarding this request to Terry Cribbe at 423-751-3850.

I declare under penalty of perjury that the foregoing is true and correct. Executed on this 10th day of August 2012.

Respectfully,

J.W. Shea
Vice President, Nuclear Licensing

Enclosures:
1. Evaluation of Proposed Changes
2. Evaluation of Issues from Pre-Application Meeting

cc (Enclosures):

NRC Regional Administrator - Region II
NRC Senior Resident Inspector – Sequoyah Nuclear Plant, Units 1 and 2
Director, Division of Radiological Health - Tennessee State Department of Environment and Conservation

ENCLOSURE 1

EVALUATION OF PROPOSED CHANGES

TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR PLANT, UNITS 1 AND 2

Subject: **Application to Revise Sequoyah Nuclear Plant (SQN) Units 1 and 2 Updated Final Safety Analysis Report Regarding Changes to Hydrologic Analysis (SQN-TS-12-02)**

ATTACHMENTS

1. Proposed SQN Units 1 and 2 UFSAR Text Changes (Markups)
2. Proposed SQN Units 1 and 2 UFSAR Tables
3. Proposed SQN Units 1 and 2 UFSAR Figures (Public)
4. Proposed SQN Units 1 and 2 UFSAR Figures (Non-Public)

ENCLOSURE 1

EVALUATION OF PROPOSED CHANGES

1.0 SUMMARY DESCRIPTION

The probable maximum flood (PMF) for SQN Units 1 and 2 at the time of Operating License issuance was elevation 722.6 ft, and included assumptions based on the existing understanding of dam structural stability and capability during seismic and extreme flood events in the 1970's. In the 1980's and 1990's, TVA implemented a Dam Safety Program (DSP) that resulted in dam safety modifications that increased dam structural stability and capability Between 1995 and 1998, TVA completed a hydrologic reanalysis to credit the results of the dam safety modifications that had been completed. This reanalysis resulted in lowering the SQN Units 1 and 2 calculated probable maximum flood (PMF) to elevation 719.6 ft, although no physical changes to SQN Units 1 and 2 site flooding protection features were implemented as a result of the decreased design basis flood (DBF) elevations.

On October 30, 2007, TVA submitted an application for a combined operating license (COLA) for the proposed Bellefonte Nuclear Plant (BLN) Units 3 and 4, in accordance with 10 CFR 52. During review of the BLN Units 3 and 4 Final Safety Analysis Report (FSAR), the NRC performed an audit of the hydrologic analysis which resulted in the issuance of three Notice of Violations (NOVs) on March 19, 2008 (Reference: NRC Letter to TVA, Bellefonte Combined License Application – Nuclear Regulatory Commission Inspection of the Implementation of the Quality Assurance Program Governing the Simulated Open Channel Hydraulics Model - Inspection Report Numbers 05200014/2008--01 and 05200015/2008-001 and Notice of Violation, Accession No. ML080640487). In response to these NOVs, TVA completed a revised hydrologic analysis to support the BLN Units 3 and 4 COLA.

As a result of the revised BLN Units 3 and 4 hydrologic analysis, the hydrologic analysis for SQN Units 1 and 2 was revised to incorporate updated input information, and updates to methodology which includes use of the U.S. Army Corps of Engineers (USACE) Hydrologic Modeling System (HEC-HMS) and River Analysis System (HEC-RAS) software. On March 1, 2010, TVA submitted Licensee Event Report 327 and 328/2009-009, "Unanalyzed Condition Affecting Probable Maximum Flood Level," Revision 0 (ML100610673) followed on April 14, 2010 with Licensee Event Report 327 and 328/2009-009, "Unanalyzed Condition Affecting Probable Maximum Flood Level," Revision 1 (ML101090017), providing details concerning an unanalyzed condition affecting the PMF level for the plant. As stated in these submittals, on December 30, 2009, the issuance of an updated calculation titled "PMF Determination for Tennessee River Watershed" increased the SQN design basis PMF level from elevation 719.6 ft to elevation 722.0 ft. This increase in calculated PMF elevation resulted from several calculational changes including updated dam rating curves using model data and changes in reservoir operating policy. A previous change had decreased the SQN PMF level from elevation 722.6 ft to elevation 719.6 ft. However, SQN remains designed for a PMF level of elevation 722.6 ft with the current exception of the applicable equipment required for flood mode operation located in the Diesel Generator Building and the Spent Fuel Pit Cooling Pump Motors. Because of the unanalyzed condition, the potential existed for SQN to exceed its DBF design basis and adversely affect plant safety. The affected calculation and supporting calculations have since been updated as a result of other necessary changes, and the current PMF level is elevation 722.0 ft.

The update of the hydrologic analysis for SQN Units 1 and 2 includes, but is not limited to, changes to the description of the current hydrosphere, use of more recent flood history information, changes to the inputs used for determining probable maximum precipitation (PMP) and resulting PMF and DBF elevations at the plant site including changes to the runoff and

stream course model, changes to the determination of seismically induced dam failure flood impacts at the plant site, changes to the analysis for determining that adequate water is available for operation of SQN Units 1 and 2, and updates to flooding protection requirements. The update to the runoff and stream course model includes updated discharge rating curves to address recently identified rim leaks for Fort Loudoun Reservoir, Watts Bar Reservoir, and Nickajack Reservoir which result in bypass flow around the respective dams. As a result of the issues and updates associated with the SQN Units 1 and 2 hydrologic analysis, the PMF elevation at the SQN site is increased from elevation 719.6 ft to 722.0 ft, and the resulting DBF elevations affecting the safety-related SQN Units 1 and 2 systems, structures, and components (SSCs) are increased. Most of the SSCs that are required to be protected from a flood are not impacted by the increased DBF elevations, because either margin remains between the DBF elevations and the elevation of the SSCs, or the existing flooding protection measures are still effective. However, there are exceptions that require compensatory measures to ensure adequate flooding protection in the interim, with documentation changes and permanent plant modifications planned to restore or gain additional margin between the revised DBF elevations and limiting safety-related SSCs.

TVA is requesting NRC review and approval of the technical changes to the SQN Units 1 and 2 UFSAR described in this enclosure to address the cumulative effects that have occurred in the SQN Units 1 and 2 hydrologic analysis since issuance of the Operating License. Specific technical changes are proposed in SQN Units 1 and 2 UFSAR Sections 2.4, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 2.4.11, 2.4.14, and Appendix 2.4A. Additional editorial changes are shown for SQN Units 1 and 2 UFSAR Section 2.4, and do not require NRC review and approval.

Attachment 1 to this enclosure provides the existing SQN Units 1 and 2 UFSAR text pages marked up to show the proposed changes. Attachment 2 provides the proposed replacement SQN Units 1 and 2 UFSAR Section 2.4 tables. Attachment 3 provides the proposed replacement SQN Units 1 and 2 UFSAR Section 2.4 figures (public version). Attachment 4 provides the proposed replacement SQN Units 1 and 2 UFSAR Section 2.4 figures (non-public version).

2.0 DETAILED DESCRIPTION

2.1 Proposed Changes

Section 2.4, Hydrological Engineering

Several technical changes are proposed to be added for SQN Units 1 and 2 UFSAR Section 2.4 to reflect the changes described further in the remaining sections. These include the following:

- Adding a discussion of the maximum flood elevation that would result from an occurrence of the probable maximum storm, which is revised from elevation 719.6 ft to elevation 722.0 ft.
- Adding information regarding coincident wind wave activity that results in wind waves of 4.2 ft high (trough to crest).
- Adding information regarding run up on the 4:1 and 15:1 slopes approaching the Diesel Generator Building reaching elevation 723.2 ft, and wind wave run up on the walls of the Auxiliary, Control and Shield Buildings reaching elevation 726.2 ft.

ENCLOSURE 1

EVALUATION OF PROPOSED CHANGES

Additional editorial changes are shown in the mark-ups provided in Attachment 1.

Section 2.4.1, Hydrological Description

The following technical changes are proposed for SQN Units 1 and 2 UFSAR Section 2.4.1 to update the hydrological description to reflect the most current information available regarding operations of the TVA system of reservoirs and dams that affect the hydrologic analysis for SQN Units 1 and 2. Additional editorial changes are shown in the mark-ups provided in Attachment 1.

Hydrosphere

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.1.2, there are 17 major reservoirs in the TVA system upstream from the plant, 13 of which have substantial reserved flood detention capacity during the main flood season. This change proposes to update the descriptions of these reservoirs with updated detention areas and capacities. The flood detention capacity reserved in the TVA system varies seasonally, with the greatest amounts during the January through March flood season. SQN Units 1 and 2 UFSAR Figures 2.4.1-4 (16 Sheets) are the original reservoir seasonal operating guides for the reservoirs above the plant site. This change provides updated figures showing the current reservoir seasonal operating guides.

Section 2.4.2, Floods

The following technical changes are proposed for SQN Units 1 and 2 UFSAR Section 2.4.2 to update the discussion of floods to reflect the most current information available regarding historical floods that affect the hydrologic analysis for SQN Units 1 and 2. Additional editorial changes are shown in the mark-ups provided in Attachment 1.

Flood History

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.2.1, flood records for the period 1952 to date can be considered representative of prevailing conditions for the Tennessee River Valley watershed under existing TVA river operations procedures. This change proposes to update the highest flow at Chickamauga Dam tailwater located downstream of the SQN Units 1 and 2 site to add additional historical flood events that have occurred since issuance of the original SQN Units 1 and 2 Operating License and corrects historical flood data. This historical information is used to calibrate the hydrologic models used for the hydrologic analysis.

Flood Design Considerations

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.2.2, the maximum PMF plant site flood level was elevation 719.6 ft, with wind waves of 4.2 ft high (trough to crest) predicted. This change proposes to increase the PMF level to elevation 722.0 ft with no change to the coincident wind wave activity that results in wind waves of 4.2 ft high (trough to crest).

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.2.2, wind wave run up during the PMF at the Diesel Generator Building was postulated to reach elevation 721.8 ft which is 0.2 ft below the operating floor elevation of 722.0 ft. The change proposed increases the DBF including wind wave run up during the PMF to elevation 723.2 ft, which is 1.2 ft above the Diesel Generator Building operating floor elevation of 722.0 ft.

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.2.2, the design basis external flood level for the Auxiliary, Control and Shield Buildings was 723.8 ft, and the DBF surge level inside the buildings was elevation 721.1 ft. The change proposed increases the design basis external flood level for the Auxiliary, Control and Shield Buildings to elevation 726.2 ft, and the DBF surge level inside the buildings to elevation 722.5 ft.

Section 2.4.3, Probable Maximum Flood (PMF) on Streams and Rivers

The following technical changes are proposed for SQN Units 1 and 2 UFSAR Section 2.4.3 to update the discussion of PMF on streams and rivers to reflect the most current information available as inputs, and to use updated methodologies such as the USACE HEC-HMS and USACE HEC-RAS software for elements of the hydrologic analysis for determining the PMF for streams and rivers for SQN Units 1 and 2. Additional editorial changes are shown in the mark-ups provided in Attachment 1.

PMF on Streams and Rivers

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.3, the PMF was determined from PMP for the watershed above the plant with consideration given to seasonal and areal variations in rainfall. This change proposes revisions to inputs and use of different methodologies for determining PMF as further described below. As a result of these changes, the PMF elevation at the plant is increased from elevation 719.6 ft to 722.0 ft, excluding wind wave effects.

Probable Maximum Precipitation (PMP)

Also as described in SQN Units 1 and 2 UFSAR Subsection 2.4.3.1, the PMF was determined from PMP for the watershed above the plant with consideration given to seasonal and areal variations. Two basic storm situations were found to have the potential to produce a maximum flood at Sequoyah Nuclear Plant. These are (1) a sequence of March storms producing maximum rainfall on the 21,400-square-mile watershed above Chattanooga, hereafter called the 21,400-square-mile storm, and (2) a sequence of March storms centered and producing maximum rains in the basin to the west of the Appalachian Divide and above Chattanooga, hereafter called the 7,980-square-mile storm. In the most recent analysis prior to this proposed change, a PMF of elevation 719.6 ft was produced by the 21,400 square-mile, with the 7,980 square-mile storm producing a PMF of elevation 718.9 ft. In the proposed change, a PMF elevation 722.0 ft is produced by the 21,400 square-mile storm, which remains the controlling PMP event. This change is due to the various input changes to the hydrologic analysis, and updates to methodology.

Precipitation Losses

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.3.2, a multi-variable relationship, used in the day-to-day river operations of the TVA system, has been applied to determine precipitation excess directly. The relationships were developed from observed data. They relate precipitation excess to the rainfall, week of the year, geographic location, and antecedent precipitation index (API). For the original study, a median API, as determined from past records, was used at the start of the antecedent storm. This change proposes revising the

inputs for defining API using an 11-year period of historical rainfall records (1997-2007) at the start of the antecedent storm.

Runoff and Stream Course Model

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.3.3, the original runoff model used to determine Tennessee River flood hydrographs at SQN was divided into 45 unit areas and included the total watershed above Chickamauga Dam downstream. Unit hydrographs are used to compute flows from the unit areas. The unit area flows are combined with appropriate time sequencing or channel routing procedures to compute inflows into the most upstream reservoirs which in turn are routed through the reservoirs using standard techniques. Resulting outflows are combined with additional local inflows and carried downstream using appropriate time sequencing or routing procedures including unsteady flow routing. This change proposes revising the runoff model to use 40 unit areas as a result of removing additional detail in modeling the subbasins on the Clinch and Holston Rivers that was not needed. The additional unit areas are not required, and validation of the runoff model is more efficient by eliminating these unnecessary modeling details. The results remain essentially the same due to the calibration of the model to the large flood events.

TVA developed the Simulated Open Channel Hydraulics (SOCH) model for flood routing calculations for the Tennessee River and selected tributaries. The SOCH computer model is the hydraulic model used to determine flood elevations at each TVA operating nuclear plant site. The SOCH model has been calibrated for main stem reservoirs, and Melton Hill and Tellico tributary reservoirs, to reasonably replicate observed river discharges and elevations for known historic events. Once calibrated, the SOCH model can be used to reliably predict flood elevations and discharges for events of other magnitudes. Additional details including specific changes to the SOCH model analysis are described below.

Tributary reservoir routings: In the original routing model, the Goodrich semigraphical method and flat pool storage conditions (except Tellico) were used. In the proposed change, the Melton Hill routing is revised to adopt unsteady flow for better refinement for dam seismic failure cases as further described in the next discussion. The Goodrich semigraphical method described in the SQN Units 1 and 2 UFSAR is the same as standard reservoir routing described in the proposed SQN Units 1 and 2 UFSAR text.

Discharge rating curves: In the original hydrologic analysis, initial dam rating curves were developed based on the existing geographical information available. In the proposed change, temporary flood barriers have been installed on the earthen embankments of four dams (Cherokee, Fort Loudoun, Tellico, and Watts Bar Reservoirs) to increase the height of embankments and are included in the discharge rating curves for these four dams. Increasing the height of embankments at these four dams prevents embankment overflow and failure of the embankment. The vendor supplied temporary flood barriers were shown to be stable for the most severe PMF headwater/tailwater conditions using vendor recommended base friction values. These temporary flood barriers are discussed in greater detail in the discussions for proposed changes to SQN Units 1 and 2 UFSAR Subsection 2.4.3.4 below. Also, there are additional rim leaks for Fort Loudoun Reservoir, Watts Bar Reservoir, and Nickajack Reservoir identified through use of the latest available geographical information system (GIS) information. These rim leaks result in bypass flow around the respective dams that are addressed in updated discharge rating curves. A single postulated Fort Loudoun Reservoir rim leak north of the Marina Saddle Dam was added as an additional discharge component for the Fort Loudoun

Dam which discharges into the Tennessee River at Tennessee River Mile (TRM) 602.3. For Watts Bar Dam, flow is considered through seven Watts Bar Reservoir rim leaks. Three of the rim leak locations discharge to Yellow Creek, entering the Tennessee River three miles downstream of Watts Bar Dam. The remaining four rim leak locations discharge to Watts Creek, which enters Chickamauga Reservoir just below Watts Bar Dam. A single postulated Nickajack Reservoir rim leak just northeast of the dam is discharged at Nickajack Dam tailwaters. The changes are made to update and refine the model.

Unsteady flow model: In the original routing model, the main river and Tellico were modeled with unsteady flow techniques, with calibration of the unsteady flow model performed using the steady flow profiles from the USACE HEC-2 backwater computer code. In the proposed change, the main river reservoirs, Tellico, and Melton Hill are modeled with unsteady flow techniques and calibrated using profiles computed from the more recent USACE HEC-RAS computer code. The change is made to adopt the most recent computer code.

Unsteady flow model - Fort Loudoun Reservoir specific discussion: In the original routing model for Fort Loudoun Reservoir, there were 24 cross-sections, verified at three gauged points using 1963 and 1973 flood data, and five cross-sections used for the Fort Loudoun and Tellico canal physically connecting the reservoirs. In the proposed change, there are 33 cross-sections with additional sections interpolated between each for a total of 59 cross-sections. The Fort Loudoun and Tellico canal was modeled using nine cross-sections with an average cross-section spacing of about 0.18 mile. The Fort Loudoun unsteady flow model was verified using the March 1973 flood data. Tellico Dam was not closed until 1979, and thus was not in place during the March 1973 flood for verification. The unsteady flow model for the Fort Loudoun-Tellico complex, which includes both reservoirs and the Fort Loudoun and Tellico canal, is verified using the May 2003 flood data. The Tellico reservoir SOCH model is also used to replicate the Federal Emergency Management Agency (FEMA) published 100-year and 500-year flood profiles as an additional calibration step.

Unsteady flow model - Cherokee and Douglas Dams specific discussion: In the original routing model, the model extended up to Douglas Dam and Cherokee Dam on the French Broad River and Holston River, respectively, with the models verified at one gauged point each using the 1963 and 1973 flood data. In the proposed change, French Broad River is modeled using 33 cross-sections with additional sections interpolated between the original cross-sections for a total of 49 cross-sections, and the Holston River is modeled using 29 cross-sections with additional sections interpolated between the original cross-sections for a total of 53 cross-sections. The French Broad River and Holston River models are verified at two gauged points each using the March 1973 flood and at one point each using the May 2003 flood. The models are also verified by replicating the FEMA published 500-year flood profiles.

Unsteady flow model – Little Tennessee River specific discussion: In the original routing model, the Little Tennessee River was modeled from Tellico Dam, mile 0.3, through Tellico Reservoir to Chilhowee Dam at mile 33.6 and upstream to Fontana Dam at mile 61.0. The model for Tellico Reservoir to Chilhowee Dam was tested for adequacy by comparing its results with steady-state profiles at 1,000,000 and 2,000,000 cfs computed by the standard-step method. Minor decreases in conveyance in the unsteady flow model yielded good agreement. The average conveyance correction found necessary in the reach below Chilhowee Dam to make the unsteady flow model agree with the standard-step method was also used in the river reach from Chilhowee to Fontana Dam. In the proposed change, the Little Tennessee River was modeled from Tellico Dam, Little Tennessee River mile (LTRM) 0.3 to Chilhowee Dam at LTRM 33.6.

EVALUATION OF PROPOSED CHANGES

The Little Tennessee River from Tellico Dam to Chilhowee Dam at LTRM 33.6 is described by 23 cross-sections with additional sections being interpolated between the original sections for a total of 49 cross-sections in the SOCH model, with a variable cross-section spacing of up to about 1.8 miles.

Unsteady flow model - Watts Bar reservoir specific discussion: In the original routing model, 34 reaches were used. In the proposed change, 39 cross-sections with two additional cross-sections in the upper reach (a total of 41 cross-sections) are used with a variable cross-section spacing of up to about 2.8 miles. The model also includes a junction with the Clinch River up to Melton Hill Dam with one additional cross-section being interpolated between each of the original 13 cross-sections.

Unsteady flow model - Junction at Tennessee River mile 601.1 to Tellico Dam at Little Tennessee River mile 0.3: This short segment of stream was not considered in the original analysis. In the proposed change, five cross-sections with spacing of 0.08 miles are added. The change is made to refine the model.

Unsteady flow model - Chickamauga reservoir specific discussion: In the original routing model, 28 reaches were used and verified at four gauged points using 1973 flood data. In the proposed change, 29 cross-sections with additional cross-sections interpolated between the original cross-sections for a total of 53 are used. The model includes a junction with the Dallas Bay arm and the Hiwassee River arm. The model is verified using both the March 1973 and May 2003 flood data. The change is made to refine the model and add unsteady flow modeling for Dallas Bay and Hiwassee River arms.

Model calibration: In the original analysis, the TVA standard-step backwater program or USACE HEC-2 software for river hydraulics (both solve the same equations, although not specified in the SQN Units 1 and 2 UFSAR) was calibrated using the March 1963 and March 1973 flood data. This model was then used to compute steady state profiles for flows up to 1,500,000 cfs. In the proposed change, steady-state profiles are computed using the USACE HEC-RAS software, using March 1973 and May 2003 flood data for verification.

Reservoir Operating Guides: In the original routing model, normal operating procedures at the time were used during the antecedent storm, including turbine and sluice discharge in tributaries. Turbine discharges were not used in main river reservoirs after large flood flows develop, because the head differentials were considered to be too small. Normal operating procedures were also used during the main storm except for turbine discharge for tributaries and main river dams. Gates were considered operable without failure. In the proposed change, turbine discharges are included in the analysis (main river and tributaries) until head differentials are too small or the respective powerhouse is flooded. Gates remain operable without failure. Previously, the point where turbine discharge was eliminated was an assumption and was not a calculated value. In the updated analysis, these points are determined using actual elevation data.

Median initial reservoir elevations: In the original routing model, median initial reservoir elevations were used at the start of the storm sequence. While not specifically stated in the original analysis, the initial median reservoir levels for the appropriate season were used. In the proposed change, the updated analysis uses the same method to determine the initial median reservoir levels. However, these median levels are different as a result of changes to the reservoir operating guidelines.

Temporary flood barriers: In the routing model described in the SQN Units 1 and 2 UFSAR, temporary flood barriers were not used and the earth embankments at the main river dams were not overtopped as a result of dam safety modifications that have been implemented since original licensing of SQN Units 1 and 2. In the proposed change, the height of embankments are physically increased using temporary flood barriers to prevent earth embankment overtopping at Cherokee, Fort Loudoun, Tellico and Watts Bar Reservoirs. While the flood barriers are "temporary structures," there is a structural analysis for the headwater loading behind the temporary flood barriers that verifies that failure of the barriers themselves would not occur. Experience data on the use of the selected temporary flood barriers during historic floods and the vendor documentation on barrier testing were evaluated prior to selection and use. Additionally, although not credited in the seismically induced dam failure analyses, a seismic evaluation completed on the flood barriers (without headwater behind the barriers) verifies that failure of the flood barriers themselves would not occur. A potential exists for runaway barges to float downstream and impact the temporary flood barriers at two of the four dams where the barriers are in place. Barges along these reservoirs are typically tied off at barge terminals or mooring cells during high flow events, such as a PMF event. The mooring facilities, however, are not designed for PMF elevations and velocities, so barges could break loose. There is no barge traffic on Cherokee Reservoir, so no potential for impact exists. The Fort Loudoun Reservoir has limited to moderate barge traffic. Using typical barge dimensions, a barge would have to weigh less than 70-80% of full load capacity in order to strike the barriers. However, the earthen embankments of the dam where the temporary flood barriers are placed are located at a distance from the main channel. The stream flow during a high flow event is directed toward the concrete overflow portion of the dam, and the barges would likely be carried by the current away from the temporary flood barriers. At the Tellico Reservoir, there is very infrequent barge traffic. Conservatively assuming there will be a barge on the reservoir, and using typical barge dimensions, a barge would have to weigh less than 40-50% of full load capacity in order to strike the barriers. However, the earthen embankments of the dam where the temporary flood barriers are placed are located at a distance from the main channel. The stream flow during a high flow event is directed toward the concrete overflow portion of the dam, and the barges would likely be carried by the current away from the temporary flood barriers. There is limited to moderate barge traffic at the Watts Bar Reservoir. An evaluation using typical barge dimensions for the Tennessee River, and conservatively assuming barges are empty (less draft allows for the barge to run closer to the top of the dam), demonstrates that barges are not likely to impact the temporary flood barriers. A spatial analysis shows that the closest edge of the temporary flood barrier would have to be at least 9.0 ft away from the upstream edge of the earthen embankment in order to prevent impact. The temporary flood barriers are located at least this distance from the edge of the earthen embankment, ensuring that there is no potential for barge impact. In summary, this qualitative evaluation of the possibility of barge impacts affecting the temporary flood barriers during a PMF event concludes that due to the physical features of the earthen embankments including width and slope, the expected direction of flows towards the dam spillway gates during the PMF event, as well as the placement of the temporary flood barriers at a sufficient distance from the main channel and from the shoreline, it is unlikely that a barge would impact any of the barriers. The temporary flood barriers are not credited in the analysis of seismically induced dam failure combinations, but are credited in the hydrologic analysis for determining the PMF.

Probable Maximum Flood Flow

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.3.4, the analysis to determine the PMF flow included evaluation of PMP over the total watershed with consideration of critical seasonal and areal variations. In the most recent analysis prior to this proposed change, the controlling PMF discharge was 1,236,000 cfs from the 21,400 square-mile storm in March with a downstream storm pattern. In the proposed change, PMF discharge is 1,331,623 cfs for the 21,400 square-mile storm in March with a downstream storm pattern. Discharge differences are due to input changes. Additional details including specific changes to the PMF flow analysis are described below.

Watts Bar and Chickamauga Dams: In the original analysis, the West Saddle Dike at Watts Bar Dam was considered to be overtopped and breached with the discharge input at Watts Bar Dam, and the Chickamauga Dam was considered to be overtopped but not postulated to fail. In the proposed change, the West Saddle Dike at Watts Bar Dam is overtopped and breached with the discharge input at the mouth of Yellow Creek, and Chickamauga Dam is overtopped but not postulated to fail. Therefore, the proposed change also revises the location where the discharge from Watts Bar West Saddle Dike breach is added back to the river. Also, additional rim leakage for Watts Bar Reservoir has been addressed in the updated hydrologic analysis. As a result, rim leakage is input at the mouth of Watts Creek, whose confluence with the Tennessee River is at TRM 528.0, or at the mouth of Yellow Creek, whose confluence with the Tennessee River is at TRM 526.82. The update is to provide a more realistic modeling configuration.

Concrete section analysis: In the original analysis, comparisons were included between design headwater and tailwater levels and those that prevail during the PMF for each dam. If overturning and horizontal forces were not increased by more than 20%, then the structures were considered safe against failure and were then excluded from further consideration. Because overturning and horizontal forces were increased greater than 20% for Douglas, Fort Loudoun and Watts Bar Dams, they were further examined and judged stable. In the proposed change, factors of safety in sliding are determined by comparison of design headwater and tailwater levels to PMF headwater and tailwater levels for each dam including those previously considered safe against failure. If the factor of safety is greater than 1.0, then the structures are considered safe against failure. Therefore, the proposed change evaluates the possibility of failure for each of the upstream dams instead of just those whose headwater/tailwater comparison were greater than 20%. This is a more comprehensive evaluation of the dams for the updated PMF levels.

Spillway gates: In the original analysis, there was limited discussion involving the radial spillway gates at Fort Loudoun and Watts Bar Dams. In the proposed change, the Watts Bar Dam spillway gates are described in general, with the yield stress and stress in trunnion pins noted to be less than allowable design stress. This is a change to add details to the SQN Units 1 and 2 UFSAR.

Waterborne Objects: In the original analysis, discussion was included for barge (end on) impacts on spillway gates and bents and broadside impacts. This information is revised in the SQN Units 1 and 2 UFSAR to more accurately reflect the engineering judgment used in evaluating potential impacts. A new subsection discussing the potential for barge impacts to the temporary flood barriers at Cherokee, Fort Loudoun, Tellico, and Watts Bar Reservoirs is also added in UFSAR Section 2.4.3.4 as previously discussed.

Lock Gates: In the original analysis, Fort Loudoun, Watts Bar and Chickamauga lock gates were examined for possible failure. This information is revised in the SQN Units 1 and 2 UFSAR to more accurately reflect the evaluation of the lock gate structural elements.

Embankment Breaching: In the original analysis, detailed discussion on the methodology used for earth embankments breach was included. The first part of the paragraph was since revised to discuss that the potential for embankment breaching was examined and no breaching would occur except Watts Bar West Saddle Dike which is completely failed. In the proposed change, this discussion is deleted since there is no other embankment breach in the current hydrologic analysis. This is a change to delete obsolete information.

Water Level Determination

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.3.5, elevations from the potential controlling PMF events were evaluated to determine the limiting PMF for the SQN site. In the most recent analysis prior to this proposed change, a PMF of elevation 719.6 ft was produced by the 21,400 square-mile storm, with the 7,980 square-mile storm producing a PMF of elevation 718.9 ft. In the proposed change, a PMF elevation 722.0 ft is produced by the 21,400 square-mile storm, which remains the controlling PMP event. This change is due to the various input changes to the hydrologic analysis, and updates to methodology.

Coincident Wind Wave Activity

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.3.6, wind waves are likely when the PMF crests. In the original analysis, wind wave and runup elevations (as well as fetch lengths to determine those levels) were given for safety-related structures. In the proposed change, updated wind wave and runup elevations are given. Methodology used is the same as the original analysis and inputs are the same except for the updated PMF stillwater elevation.

Section 2.4.4, Potential Dam Failures, Seismically Induced

The following technical changes are proposed for SQN Units 1 and 2 UFSAR Section 2.4.4 to update the discussion of potential flood levels from seismically induced dam failures to reflect the most current information available as inputs, and to use updated methodologies such as the USACE HEC-HMS and USACE HEC-RAS software for elements of the hydrologic analysis for determining dam failure outflows from tributary dams for SQN Units 1 and 2. Additional editorial changes are shown in the mark-ups provided in Attachment 1.

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.4, procedures described in Appendix A of Regulatory Guide (RG) 1.59 were followed when evaluating potential flood levels from seismically induced dam failures. Site flooding levels at SQN from potential seismically induced dam failures are determined using the SOCH model, with changes previously discussed regarding the proposed change to the runoff and stream course model.

Also as described in SQN Units 1 and 2 UFSAR Subsection 2.4.4, the original discussion included general information concerning the TVA inspection and maintenance program. In the proposed change, the TVA DSP, which is consistent with the Federal Guidelines for Dam Safety, is described in detail. As part of the TVA DSP, inspection and maintenance activities

are carried out on a regular schedule to confirm the dams are maintained in a safe condition. This is a change to add details to the SQN Units 1 and 2 UFSAR.

Dam Failure Permutations

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.4.1, analyses to determine dam integrity during seismic events were performed to determine site flooding levels at SQN from potential seismically induced dam failures.

In the analyses, two basic conditions are used, including:

1. Determination of the water level at the plant during one-half the PMF during an operating basis earthquake (OBE).
2. Determination of the water level at the plant during a 25-year flood during a safe shutdown earthquake (SSE).

The OBE and SSE are defined in SQN Units 1 and 2 UFSAR Subsection 2.5.2.4 as having maximum horizontal rock acceleration levels of 0.09 g and 0.18 g respectively. The one-half PMF as used in the analyses is developed by taking half of the rainfall-induced PMF inflows calculated from the controlling 21,400 square mile March downstream centered design storm, which consists of a three-day antecedent storm, three-day dry period, and a three-day main storm. At the start of the antecedent storm, the reservoirs are at the initial median levels used as inputs to the rainfall-induced PMF analysis. This is consistent with the guidance of RG 1.59, Revision 2.

In the most recent analysis prior to this proposed change, only two combinations of potential seismically induced dam failures were determined to cause a flood elevation above plant grade elevation. These include the OBE failure of Fontana, Hiwassee, Apalachia, and Blue Ridge Dams in the one-half SSE concurrent with a one-half PMF and the SSE failure of Norris, Cherokee and Douglas Dams concurrent with the 25-year flood. In the proposed change, the analyses are updated to include Tellico Dam failure in the originally controlling combinations as a conservative assumption, and a reduced partial failure of Fontana Dam.

In the updated analysis, there are four controlling combinations of potential seismically induced dam failures during one-half the PMF during an OBE, including:

- Norris and Tellico Dams;
- Fontana and Tellico Dams;
- Fontana, Tellico, Hiwassee, Apalachia, and Blue Ridge Dams; and
- Cherokee, Douglas, and Tellico Dams.

In the updated analysis, there is one controlling combination of potential seismically induced dam failures during a 25-year flood during a SSE, which is failure of the Norris, Cherokee, Douglas, and Tellico Dams.

Based on the updated hydrologic analysis, the peak water surface elevation at SQN is produced by the controlling combination of failure of Cherokee, Douglas, and Tellico Dams during one-half the PMF during an OBE at elevation 708.6 ft. The controlling combination for shortest wave travel time is the Fontana, Tellico, Hiwassee, Apalachia, and Blue Ridge Dams during a one-half PMF during an OBE at 32 hours

Combinations of seismic induced dam failures have changed due to the input updates and the inclusion of Tellico into the failure scenario. Specific changes include the following:

Fontana Dam failure: In the original analysis, partial failure was postulated to occur using engineering judgment. In the proposed change, partial failure to a higher elevation is postulated due to modifications of the dam, and additional analysis.

Tellico Dam failure: In the original analysis, Tellico Dam was judged to be stable for OBE seismic events. In the proposed change, Tellico Dam is postulated to fail for seismic events due to lack of supporting analysis. Tellico Dam failure is combined with each seismic failure case resulting in a bounding case.

Seismic Outflow Hydrograph for Norris, Cherokee, Douglas and Fontana Dams: In the original analysis, outflow from Norris, Cherokee, Douglas and Fontana Dams was based on a SOCH unsteady flow model developed in sufficient detail to define outflow from postulated dam failure. In the proposed change, outflow from Norris, Cherokee, Douglas, and Fontana Dams is based on USACE HEC-HMS software model using the same dam failure rating curves for Norris, Cherokee, and Douglas Dams, and a revised dam failure rating curve for Fontana Dam for partial failure at a higher elevation, with results validated by comparing results with TRBROUTE. Use of USACE HEC-HMS storage routing versus unsteady flow is a different method, but provides essentially the same result.

<u>Unsteady Flow Analysis of Potential Dam Failures</u>

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.4.2, unsteady flow routing techniques were used to evaluate plant site flood levels from postulated seismically induced dam failures wherever their inherent accuracy was needed. In the proposed change, the HEC-HMS storage routing is used to compute the outflow hydrograph from the postulated failure of each dam except main river dams. For Tellico Dam, the complete failure is analyzed with the SOCH model. The failure time and initial reservoir elevations for each dam are determined from a pre-failure TRBROUTE analysis. HEC-HMS is used to develop the post failure outflow hydrographs based on the previously determined dam failure rating curves. The outflow hydrographs are validated by comparing the HEC-HMS results with those generated by simulations using TRBROUTE. This additional detail for the unsteady flow routing techniques is provided for completeness.

<u>Water Level at Plant Site</u>

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.4.3, the unsteady flow analyses of the postulated combinations of seismic dam failures coincident with floods analyzed yielded a maximum elevation of 707.9 ft excluding wind wave effects. In the proposed change, the maximum elevation excluding wind wave effects is increased to elevation 708.6 ft from the one controlling combination of failure of Cherokee, Douglas, and Tellico Dams during one-half the PMF during an OBE. Coincident wind wave activity is required by the guidance in RG 1.59 to

be addressed in determining whether rainfall induced PMF events or seismically induced dam failure flood events are the bounding event for design of flooding protection features. However, wind wave activity on the order calculated for rainfall induced PMF events if added on top of the limiting elevation of 708.6 ft for seismically induced dam failure flood events would still result in water surface elevations several feet below the rainfall induced PMF elevation of 722.0 ft described in UFSAR Section 2.4.3. Therefore, based on this qualitative analysis, the rainfall induced PMF elevation of 722.0 ft is bounding for SQN Units 1 and 2.

Sections 2.4.5 through 2.4.10

Editorial changes for SQN Units 1 and 2 UFSAR Sections 2.4.5 through 2.4.10 are shown in the mark-ups provided in Attachment 1. In addition, the name of the TVA Water Management Organization is changed to TVA River Operations (RO) to reflect the current organization name. There are no technical changes proposed for these sections.

Section 2.4.11, Low Water Considerations

The following technical changes are proposed for SQN Units 1 and 2 UFSAR Section 2.4.11 to update the discussion of low water considerations to reflect the most current information for the hydrologic analysis for SQN Units 1 and 2. Additional editorial changes are shown in the mark-ups provided in Attachment 1.

Low Flow in Rivers and Streams

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.11.1, analyses are performed to determine probable minimum water level at SQN Units 1 and 2 and the minimum flow requirement at the essential raw cooling water (ERCW) intake. In the original analysis, water level at the SQN site upon complete dam failure of the south embankment of Chickamauga Dam resulting in a breach width of five times the dam height from an initial Chickamauga Reservoir pool elevation 682.5 ft (normal summer level) began to drop in one hour and reached elevation 641.0 ft (minimum river elevation originally assumed for required minimum level in the ERCW intake canal) in 60 hours. In the proposed change, water level at the SQN site upon complete dam failure of the south embankment of Chickamauga Dam resulting in a breach width of 400 ft from an initial Chickamauga Reservoir pool elevation of 681.0 ft (slightly below the normal summer pool elevation and the normal summer pool elevation in Nickajack Reservoir) begins to drop in 0.5 hours and reaches elevation 641.0 ft (minimum river elevation for required minimum level in the ERCW intake canal) in 51 hours. This change includes updates to the routing model cross-sectional data using new bathymetry and recalibration of the models. The timing changes are due to these updates to the model. This value is determined by postulating loss of Chickamauga Dam and no flow from Watts Bar Dam.

Historical Low Water

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.11.3, historical low water records for SQN Units 1 and 2 at the site intakes are provided. In the original analysis, average daily flows less than 5,000 cfs were determined to occur 0.65% of the time, and average daily flows less than 10,000 cfs were determined to occur 5.19% of the time. In the proposed change, average daily flows less than 5,000 cfs are determined to occur 0.70% of time, and average daily flows less than 10,000 cfs are determined to occur 7.30% of the time. This update is based on analysis of additional years of record.

Sections 2.4.12 and 2.4.13

Editorial changes for SQN Units 1 and 2 UFSAR Sections 2.4.12 and 2.4.13 are shown in the mark-ups provided in Attachment 1. There are no technical changes proposed for these sections.

Section 2.4.14, Flooding Protection Requirements

The following technical changes are proposed for SQN Units 1 and 2 UFSAR Section 2.4.14 and Appendix 2.4A to update the discussion of flooding protection requirements to reflect the most current information for the hydrologic analysis for SQN Units 1 and 2. The content of SQN Units 1 and 2 UFSAR Appendix 2.4A as proposed to be revised is relocated to SQN Units 1 and 2 UFSAR Section 2.4.14 to be consistent with NUREG-0800, Standard Review Plan (SRP). Additional editorial changes are shown in the mark-ups provided in Attachment 1.

Flooding Protection Requirements

As described in SQN Units 1 and 2 UFSAR Appendix 2.4A, Subsection 2.4A.1, an evaluation is performed to determine the methods by which the SQN is capable of tolerating floods above plant grade without jeopardizing public safety. The DBF is the calculated upper-limit flood that includes the PMF plus the wave runup caused by a 45 mph overland wind as discussed in SQN Units 1 and 2 UFSAR Subsection 2.4.3.6. As a result of the changes to inputs and methodology discussed previously, the DBF elevations at various plant locations that would result for the controlling PMF are increased from those currently provided in the SQN Units 1 and 2 UFSAR as follows:

Plant Location	Current DBF Level (ft.)	New DBF Level (ft.)
Probable Maximum Flood (still reservoir)	719.6	722.0
DBF Runup on Diesel Generator Building	721.8	723.2
DBF Runup on vertical external, unprotected walls	723.8	726.2
DBF Surge level within flooded structures	720.1	722.5

Warning Plan

As described in SQN Units 1 and 2 UFSAR Appendix 2.4A, Subsection 2.4A.3, plant grade elevation 705.0 ft can be exceeded by rainfall floods and closely approached by seismically induced dam failure floods. A warning plan is needed to assure plant safety from these floods. In the proposed change, the warning time for SQN has been reevaluated because the initial median reservoir levels and flood operational guides have been revised, dam rating curves have changed at some dams, and the SOCH model of the Tennessee River has been updated to meet current quality assurance standards. Based on the current hydrologic analysis, the following specific changes are required to the warning plan analysis and results:

Rainfall Floods: As described in SQN Units 1 and 2 UFSAR Appendix 2.4A, Subsection 2.4A.3.1, protection of SQN from rainfall floods that might exceed plant grade utilizes a flood warning issued by TVA's Water Management. TVA's climatic monitoring and flood predicting systems and flood control facilities permit early identification of potentially

critical flood producing conditions and reliable prediction of floods which may exceed plant grade well in advance of the event. In the proposed change, the organizational title is changed to TVA River Operations (RO), and the forecasted levels for issuing Stage I and Stage II warnings are changed to reflect the updated hydrological basis for the warning plan as described further in SQN Units 1 and 2 UFSAR Subsection 2.4.14.9.4.

Seismically-Induced Dam Failure Floods: As described in SQN Units 1 and 2 UFSAR Appendix 2.4A, Subsection 2.4A.3.2, only two postulated combinations of seismically induced dam failures and coincident storm conditions were shown to result in a flood which could exceed elevation 705.0 ft at the plant. In the proposed change, four postulated combinations of seismically induced dam failures are considered to reflect the updated hydrological basis for the warning plan as described further in SQN Units 1 and 2 UFSAR Subsection 2.4.14.9.4.

<u>Basis for Flood Protection Plan in Rainfall Floods</u>

As described in SQN Units 1 and 2 UFSAR Appendix 2.4A, Subsection 2.4A.8, large Tennessee River floods can exceed plant grade elevation 705.0 ft at SQN, and plant safety in such an event requires shutdown procedures which may take 24 hours to implement. TVA flood forecast procedures are used to provide at least 27 hours of warning before river levels reach elevation 703.0 ft. Use of elevation 703.0 ft, 2.0 ft below plant grade, provides enough margin to prevent wind generated waves from endangering plant safety during the final hours of shutdown activity. As previously stated, this information as proposed to be revised is relocated to SQN Units 1 and 2 UFSAR Subsection 2.4.14. Based on the current hydrologic analysis, the following specific changes are required to the warning plan analysis and results for rainfall floods:

Overview: As described in SQN Units 1 and 2 UFSAR Appendix 2.4A, Subsection 2.4A.8, the estimated probability is less than 0.0026 that a Stage I warning could possibly be issued during the 40-year life of the plant. In the proposed change, no probability is quoted since there is no regulatory requirement or regulatory guidance to determine the probability.

TVA Forecast System: As described in SQN Units 1 and 2 UFSAR Appendix 2.4A, Subsection 2.4A.8, TVA has in constant use an extensive, effective system to forecast flow and elevation as needed in the Tennessee River basin monitored by TVA RO. This permits efficient operation of the reservoir system and provides warning of when water levels could possibly exceed critical elevations at selected, sensitive locations. In the original SQN Units 1 and 2 UFSAR text, there was an extensive description of process, gage network, and forecast procedures. In the proposed change, updates are included to reflect current processes, gage network and forecast procedures. These changes reflect refinements which have been implemented into the process over time.

Basic Analysis: As described in SQN Units 1 and 2 UFSAR Appendix 2.4A, Subsection 2.4A.8, the forecast procedure to assure safe shutdown of SQN for flooding is based upon an analysis of 17 hypothetical PMP storms, including their antecedent storms. In the proposed change, the procedure is based upon an analysis of nine of the 17 hypothetical storms up to PMP magnitude judged to be controlling. This change reflects the updated hydrological basis for the warning plan as described further in SQN Units 1 and 2 UFSAR Subsection 2.4.14.9.4.

Hydrologic Basis for Warning System: As described in SQN Units 1 and 2 UFSAR Appendix 2.4A, Subsection 2.4A.8, a minimum of 27 hours has been allowed for preparation of

the plant for operation in the flood mode. An additional 4 hours for communication and forecasting computations is provided to translate rain on the ground to river elevations at the plant. Hence, the warning plan provides 31 hours from arrival of rain on the ground until elevation 703.0 ft could be reached. The 27 hours allowed for shutdown at the plant consists of a minimum of 10 hours of Stage I preparation and an additional 17 hours for Stage II preparation that is not concurrent with the Stage I activity. The threshold river levels at SQN for initiating Stage I and Stage II preparations differ with the season. In the original analysis, during the October 1 – April 15 "winter" season, Stage I threshold elevation was 697.0 ft. Corresponding Stage I threshold river elevation of the April 16 – September 30 "summer" season was elevation 703.0 ft. In the proposed change, during the "winter" season, Stage I threshold elevation is 694.5 ft. Corresponding Stage I threshold river elevation for the "summer" season at SQN is elevation 699.0 ft. The specific periods (October 1 – April 15 and April 16 – September 30) were judged to be too rigid and elevations changes are a result of updated analysis which change the curve and subsequently change the threshold elevations. This change is due to the various input changes to the hydrologic analysis, and as a result of the updates to methodology.

Hydrologic Basis for Threshold Flood Warning Levels: As described in SQN Units 1 and 2 UFSAR Appendix 2.4A, Subsection 2.4A.8, predicted threshold flood warning levels which assure adequate shutdown times are evaluated. In the original analysis, the procedure for establishing the threshold levels for SQN shutdown was described with a threshold level in winter at elevation 697.0 ft (Stage I) and 703.0 ft (Stage II), and summer at elevation 703.0 ft (Stage I) and 703.0 ft (Stage II). In the proposed change, the procedure for establishing the threshold levels for SQN shutdown is described with a threshold level in winter at elevation 694.5 ft (Stage I) and 703.0 ft (Stage II), and in summer at elevation 699.0 ft (Stage I) and 703.0 ft (Stage II). This change is due to the various input changes to the hydrologic analysis, and as a result of the updates to methodology.

Communications Reliability: As described in SQN Units 1 and 2 UFSAR Appendix 2.4A, Subsection 2.4A.8, communication between projects in the TVA power system is via: (a) TVA-owned microwave network, (b) Fiber-Optics System, and (c) by commercial telephone. In emergencies, additional communication links are provided by Transmission Power Supply radio networks. The four networks provide a high level of dependability against emergencies. In the original description of the communications systems, the original technology was described. In the proposed change, the description is updated to reflect current technology.

Basis for Flood Protection Plan in Seismic-Caused Dam Failures: As described in SQN Units 1 and 2 UFSAR Appendix 2.4A, Subsection 2.4A.9, floods resulting from combined seismic and flood events can closely approach plant grade, thus requiring emergency measures. In the most recent analysis previous to this update, only two seismic dam failure combinations coincident with a flood, i.e., the failure of Fontana, Hiwassee, Apalachia, and Blue Ridge Dams in the one-half SSE (i.e., OBE) concurrent with a one-half PMF and the SSE failure of Norris, Cherokee and Douglas Dams concurrent with the 25-year flood, would result in a flood approaching plant grade. In the proposed change, plant grade would be exceeded by four of five candidate combinations. This change is due to the various input changes to the hydrologic analysis, and as a result from the updates to methodology.

ENCLOSURE 1

EVALUATION OF PROPOSED CHANGES

Section 2.4 Tables

In support of the technical changes proposed for the SQN Units 1 and 2 UFSAR, and to reflect the most current information for the hydrologic analysis for SQN Units 1 and 2, the tables associated with SQN Units 1 and 2 UFSAR are proposed to be revised as follows:

- SQN Units 1 and 2 UFSAR Table 2.4.1-1, Facts About Major TVA Dams and Reservoirs (Historical Information), is revised to incorporate the latest information for the TVA system dams and reservoirs. The revised table is also renamed to delete the "Historical Information" reference and to delete the word "Major," reformatted using a more recent word processing program, and renumbered as Table 2.4.1-2 to be in the correct sequence for this section.

- SQN Units 1 and 2 UFSAR Table 2.4.1-2, Facts About Non-TVA Dams and Reservoir Projects (Historical Information), is renamed to delete the "Historical Information" reference, reformatted using a more recent word processing program, and renumbered as Table 2.4.1-5 to be in the correct sequence for this section. There are no technical changes to the table.

- SQN Units 1 and 2 UFSAR Table 2.4.1-3, Flood Detention Capacity TVA Projects Above Sequoyah Nuclear Plant Storage Reserved for Flood Control in Acre - Feet, is revised to incorporate the latest information for the TVA system projects above the SQN site. The revised table is also reformatted using a more recent word processing program, and renumbered as Table 2.4.1-6 to be in the correct sequence for this section.

- A new SQN Units 1 and 2 UFSAR Table 2.4.1-3, TVA Dams - River Mile Distances to SQN, is added.

- SQN Units 1 and 2 UFSAR Table 2.4.1-4, Public and Industrial Surface Water Supplies Withdrawn from the 98.6 Mile Reach of the Tennessee River Between Dayton Tennessee and Meade Corp. Stevenson Ala. (Historical Information), is revised to incorporate the latest information for these surface water supplies. The revised table renamed to delete the "Historical Information" reference and is also reformatted using a more recent word processing program, and renumbered as Table 2.4.1-1 to be in the correct sequence for this section.

- A new SQN Units 1 and 2 UFSAR Table 2.4.1-4, Facts about TVA Dams Above Chickamauga, is added.

- SQN Units 1 and 2 UFSAR Table 2.4.1-5, Dam Safety Modification Status (Hydrologic), is deleted because the information provided is not appropriate information for the SQN Units 1 and 2 UFSAR.

- A new SQN Units 1 and 2 UFSAR Table 2.4.2-1, Peak Streamflow of the Tennessee River at Chattanooga, TN (USGS Station 03568000) 1867 - 2007, is added.

- SQN Units 1 and 2 UFSAR Table 2.4.3-1, Probable Maximum Storm Rainfall and Precipitation Excess, is revised to incorporate the latest information for the determination of these inputs to the hydrologic analysis. The revised table is also renamed to replace

"Rainfall" with "Precipitation," reformatted using a more recent word processing program, and renumbered as Table 2.4.3-2 to be in the correct sequence for this section.

- A new SQN Units 1 and 2 UFSAR Table 2.4.3-1, Seasonal Variations of Rainfall (PMP), is added.

- SQN Units 1 and 2 UFSAR Table 2.4.3-2, Unit Hydrograph Data, is revised to incorporate the latest information for the unit hydrograph data used in the hydrologic analysis. The revised table is also reformatted using a more recent word processing program, and renumbered as Table 2.4.3-4 to be in the correct sequence for this section.

- A new SQN Units 1 and 2 UFSAR Table 2.4.3-3, Historical Flood Events, is added.

- SQN Units 1 and 2 UFSAR Table 2.4.4-1 Floods from Postulated Seismic Failure of Upstream Dams (Plant Grade is Elevation 705), is revised to incorporate the latest information for the results of the flood analysis. The revised table is also reformatted using a more recent word processing program.

- SQN Units 1 and 2 UFSAR Table 2.4.13-1, Well and Spring Inventory Within 2-mile Radius of Sequoyah Nuclear Plant Site (Historical Information), is renamed to delete the "Historical Information" reference and replace with "1972 Survey Only," and reformatted using a more recent word processing program. There are no technical changes to the table.

- SQN Units 1 and 2 UFSAR Table 2.4.13-2, Ground Water Supplies Within 20 Mile Radius of the Plant Site (Historical Information), is renamed to delete the "Historical Information" reference and replace with "1972 Survey Only," and reformatted using a more recent word processing program. There are no technical changes to the table.

- SQN Units 1 and 2 UFSAR Table 2.4A-2, Critical Cases - Seismic Caused Dam Failures Time Between Seismic Event and Selected Plantsite Flood Elevation, is revised to incorporate the latest information for the results of the flood analysis, is reformatted using a more recent word processing program, and is renumbered as Table 2.4.14-1 to be in the correct sequence for this section.

<u>Section 2.4 Figures</u>

In support of the technical changes proposed for the SQN Units 1 and 2 UFSAR, and to reflect the most current information for the hydrologic analysis for SQN Units 1 and 2, the figures associated with SQN Units 1 and 2 UFSAR are proposed to be revised as follows:

- SQN Units 1 and 2 UFSAR Figures 2.4.1-1 through 2.4.1-3 are updated to reflect current information, with titles changed and renumbered if necessary to be in proper order. The information provided by the SQN Units 1 and 2 UFSAR figures is not necessary to support the updated hydrologic analysis.

- New SQN Units 1 and 2 UFSAR Figures 2.4.1-3 and 2.4.1-5 are added to include information of the watershed above SQN including reservoir elevation and storage relationships used as inputs to the updated hydrologic analysis.

- SQN Units 1 and 2 UFSAR Figure 2.4.2-1 is updated to reflect current information, with title changed. The information provided by the figure is not necessary to support the updated hydrologic analysis.

- SQN Units 1 and 2 UFSAR Figures 2.4.3-1 through 2.4.3-3, 2.4.3-5 through 2.4.3-9, 2.4.3-11, and 2.4.3-12 are updated to reflect current information, with titles changed and renumbered if necessary to be in proper order. The information provided by the figures reflect current TVA RO operating guidelines and revised input assumptions and model changes in support of the updated hydrologic analysis.

- SQN Units 1 and 2 UFSAR Figures 2.4.3-4, 2.4.3-10, and 2.4.3-14 are deleted and not used. The information provided by the figures is not necessary in the updated hydrologic analysis, and the figures are not referenced in the proposed SQN Units 1 and 2 UFSAR text.

- New SQN Units 1 and 2 UFSAR Figures 2.4.3-7 through 2.4.3-11, 2.4.3-13, 2.4.3-14, 2.4.3-16, 2.4.3-17, and 2.4.3-20 are added to include information regarding the models used in the updated hydrologic analysis.

- SQN Units 1 and 2 UFSAR Figures 2.4.3-13a, 2.4.3-15, 2.4.3-16, and 2.4.3-17 are renumbered as 2.4.3-22, 2.4.3-24, 2.4.3-25, and 2.4.3-26, respectively, without any technical changes.

- SQN Units 1 and 2 UFSAR Figure 2.4.4-1 title is added without any technical changes.

- SQN Units 1 and 2 UFSAR Figures 2.4.4-3, 2.4.4-6, 2.4.4-8, 2.4.4-17, 2.4.4-21, 2.4.4-30, and 2.4.4-37 through 2.4.4-39 are deleted and not used. The information provided by the figures is not necessary in the updated hydrologic analysis, and the figures are not referenced in the proposed SQN Units 1 and 2 UFSAR text.

- SQN Units 1 and 2 UFSAR Figures 2.4.4-5, 2.4.4-11, 2.4.4-16, 2.4.4-25, and 2.4.4-27 are updated to reflect current information, with titles changed and renumbered to be in proper order. The information provided by the figures reflects current analysis of dam and embankment stability in support of the updated hydrologic analysis.

- New SQN Units 1 and 2 UFSAR Figures 2.4.4-18 and 2.4.4-20 are added to include information regarding the dam failure permutations and assumptions used in the updated hydrologic analysis.

- SQN Units 1 and 2 UFSAR Figures 2.4.4-29 and 2.4.4-31 are renumbered as 2.4.4-17 and 2.4.4-19, respectively, without any technical changes.

- SQN Units 1 and 2 UFSAR Figures 2.4.4-2, 2.4.4-7, 2.4.4-9, 2.4.4-10, 2.4.4-12 through 2.4.4-15, 2.4.4-18, 2.4.4-24, 2.4.4-26, and 2.4.4-28 are renumbered as 2.4.4-22, 2.4.4-23, 2.4.4-4, 2.4.4-5, 2.4.4-7 though 2.4.4-10, 2.4.4-12, 2.4.4-13, 2.4.4-15, and 2.4.4-16, respectively, with the titles changed as necessary.

- SQN Units 1 and 2 UFSAR Figure 2.4.8-1 is not revised.

- SQN Units 1 and 2 UFSAR Figures 2.4.13-1 and 2.4.13-2 are not revised.

- SQN Units 1 and 2 UFSAR Figures 2.4A-2 and 2.4A-3 are renumbered as 2.4.14-1 and 2.4.14-2, respectively, without any technical changes.
- SQN Units 1 and 2 UFSAR Figure 2.4A-4 is updated to reflect current information, with title changed and renumbered as Figure 2.4.14-3. The information provided by the figure reflects current analysis of flood warning times in support of the updated hydrologic analysis.

2.2 Need for Proposed Changes

On October 30, 2007, TVA submitted an application for a combined operating license (COLA) for the proposed Bellefonte Nuclear Plant (BLN) Units 3 and 4, in accordance with 10 CFR 52. During review of the BLN Units 3 and 4 Final Safety Analysis Report (FSAR), the NRC performed an audit of the hydrologic analysis which resulted in the issuance of three NOVs on March 19, 2008 (Reference: NRC Letter to TVA, Bellefonte Combined License Application – Nuclear Regulatory Commission Inspection of the Implementation of the Quality Assurance Program Governing the Simulated Open Channel Hydraulics Model - Inspection Report Numbers 05200014/2008-001 and 05200015/2008-001 and Notice of Violation, Accession No. ML080640487). In response to these NOVs, TVA completed a revised hydrologic analysis to support the BLN Units 3 and 4 COLA. The revised TVA hydrologic analysis included reconstitution of the inputs and updates to calculations and software, and is documented in TVA quality-related calculations prepared, reviewed, and approved in accordance with an approved 10 CFR 50, Appendix B Quality Assurance program.

As a result of the revised BLN Units 3 and 4 hydrologic analysis, the hydrologic analysis for SQN Units 1 and 2 was revised to incorporate updated input information, and updates to methodology which includes use of the USACE HEC-HMS and USACE HEC-RAS software. On March 1, 2010, TVA submitted Licensee Event Report 327 and 328/2009-009, "Unanalyzed Condition Affecting Probable Maximum Flood Level," Revision 0 (ML100610673) followed on April 14, 2010 with Licensee Event Report 327 and 328/2009-009, "Unanalyzed Condition Affecting Probable Maximum Flood Level," Revision 1 (ML101090017), providing details concerning an unanalyzed condition affecting the PMF level for the plant. As stated in these submittals, on December 30, 2009, the issuance of an updated calculation titled "PMF Determination for Tennessee River Watershed" increased the SQN design basis PMF level from elevation 719.6 ft to elevation 722.0 ft. This increase in calculated PMF elevation resulted from several calculational changes including updated dam rating curves using model data and changes in reservoir operating policy. A previous change had decreased the SQN PMF level from elevation 722.6 ft to elevation 719.6 ft. However, SQN remains designed for a PMF level of elevation 722.6 ft with the current exception of the applicable equipment required for flood mode operation located in the Diesel Generator Building and the Spent Fuel Pit Cooling Pump Motors. Because of the unanalyzed condition, the potential existed for SQN to exceed its DBF design basis and adversely affect plant safety. The affected calculation and supporting calculations have since been updated as a result of other necessary changes, and the current PMF level is elevation 722.0 ft. The proposed changes are also necessary to address the cumulative effects that have occurred in the SQN Units 1 and 2 hydrologic analysis since issuance of the Operating License. TVA is requesting NRC review and approval of the technical changes to the SQN Units 1 and 2 UFSAR described in this enclosure, specifically the technical changes proposed in SQN Units 1 and 2 UFSAR Sections 2.4, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 2.4.11,

and 2.4.14, and Appendix 2.4A, to incorporate the cumulative effects that have occurred in the SQN Units 1 and 2 hydrologic analysis since issuance of the Operating License.

3.0 TECHNICAL EVALUATION

3.1 Evaluation

Section 2.4, Hydrologic Engineering

This section provides a summary of information that is more explicitly discussed in the applicable subsections. The justification for the changes in these sections is provided in the applicable subsections below.

Section 2.4.1, Hydrological Description

The proposed changes to SQN Units 1 and 2 UFSAR Section 2.4.1 update the hydrological description of the TVA system upstream of the SQN site, and update figures showing the current TVA reservoir seasonal operating guides. These changes are updates to the inputs used for the hydrologic analysis to reflect the most current information available regarding operations of the TVA system of reservoirs and dams, and do not represent any changes to the methodologies used in the updated hydrologic analysis. These changes represent the most current, complete, and substantiated information relative to the hydrologic description in the vicinity of the site and site regions important to the design and siting of SQN Units 1 and 2 as expected for review by the NRC in NUREG-0800, Standard Review Plan (SRP), Section 2.4.1.

Section 2.4.2, Floods

The proposed changes to SQN Units 1 and 2 UFSAR Section 2.4.2 update the discussion of historical floods that affect the hydrologic analysis for SQN Units 1 and 2. These changes are updates to the inputs used for the hydrologic analysis to reflect the most current information available, and do not represent any changes to the methodologies used in the updated hydrologic analysis. These changes represent the most current, complete, and substantiated information relative to the local intense precipitation, flooding causal mechanisms, and the controlling flooding mechanism important to the design and siting of SQN Units 1 and 2 as expected for review by the NRC in SRP Section 2.4.2.

Section 2.4.3, Probable Maximum Flood (PMF) on Streams and Rivers

The proposed changes to SQN Units 1 and 2 UFSAR Section 2.4.3 update the discussion of PMF on streams and rivers to reflect the most current information available as inputs, and to use updated methodologies such as the USACE HEC-HMS and USACE HEC-RAS software for elements of the hydrologic analysis for determining the PMF for streams and rivers for SQN Units 1 and 2. As a result of these changes, PMF elevation at the plant is increased from elevation 719.6 ft to 722.0 ft, excluding wind wave effects.

The design basis PMF event for SQN is based on storms with the heavy rainfall occurring in the middle of the three-day main storm (adopted distribution). This time distribution is supported by evaluation of actual storm events which have occurred in the region and is consistent with regulatory guidance and accepted practice.

Inputs to the simulations include calibrated SOCH models (geometry files and Manning's *n* values) of each reservoir, operational guides and initial median reservoir levels, initial dam rating curves, as well as inflow hydrographs. The model is divided into three segments for ease of computation. Segment 1 is the model comprising Fort Loudoun-Tellico, Melton Hill and Watts Bar reservoirs. Segment 1a is the model comprising the Melton Hill, Watts Bar and Chickamauga reservoirs. Segment 2 is the model comprising the Chickamauga, Nickajack, and Guntersville reservoirs. Watts Bar Dam is an appropriate location to divide Segments 1 and 2 of the model, because there is not a significant submergence effect by the tailwater on the discharge from Watts Bar Dam that would require modeling simultaneously with the downstream dam unless the concrete wall at Watts Bar Dam fails due to overtopping. If the concrete wall failure occurs, Segment 1a is required to model the submergence effects at Watts Bar Dam.

Initial dam rating curves have been developed for six main stem dams and one tributary dam (Melton Hill Dam) to be used as inputs to the SOCH models. The initial dam rating curves were developed using an average tailwater to determine outflow from the dam based on data from steady-state profiles at varying flows. In modeling the design storms it is necessary to adjust some of the initial dam rating curves to more accurately account for the submergence effect of the tailwater on the discharge that may occur at the dams during a large flood event.

A SOCH model analysis of hypothetical storms on the Tennessee River Watershed above the Guntersville Dam was conducted using the methodology described above. The current lock configuration with 18 spillway bays was used for modeling Chickamauga Dam. Additional details including specific changes to the SOCH model analysis are described in Section 2.1 of this enclosure.

These changes represent the most current, complete, and substantiated information relative to the probable maximum flooding on streams and rivers important to the design and siting of SQN Units 1 and 2 as expected for review by the NRC in SRP Section 2.4.3.

<u>Section 2.4.4, Potential Dam Failures, Seismically Induced</u>

The proposed changes to SQN Units 1 and 2 UFSAR Section 2.4.4 update the discussion of potential flood levels from seismically induced dam failures to reflect the most current information available as inputs, and to use updated methodologies such as the USACE HEC-HMS and USACE HEC-RAS software for elements of the hydrologic analysis for determining dam failure outflows from tributary dams for SQN Units 1 and 2.

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.4, procedures described in Appendix A of RG 1.59 were followed when evaluating potential flood levels from seismically induced dam failures. Site flooding levels at SQN from potential seismically induced dam failures are determined using the SOCH computer hydraulic model, with changes previously discussed regarding the proposed change to the runoff and stream course model in SQN Units 1 and 2 UFSAR Subsection 2.4.3.

In the updated hydrologic analysis, the following bounding combinations are used for evaluating potential flood levels from seismically induced dam failures:

A Seismic failures of Tellico Dam and Norris Dam during one-half the PMF during an OBE.

B Seismic failures of Tellico Dam, Norris Dam, Cherokee Dam, and Douglas Dam during a 25-year flood during a SSE.

E Seismic failure of Tellico Dam and partial seismic failure of Fontana Dam during one-half the PMF during an OBE.

F Partial seismic failure of Fontana Dam and seismic failures of Tellico Dam, Hiwassee Dam, Apalachia Dam, and Blue Ridge Dam during one-half the PMF during an OBE.

H Seismic failures of Cherokee Dam, Douglas Dam, and Tellico Dam during one-half the PMF during an OBE.

A SOCH model analysis of these bounding dam failure combinations was conducted using the methodology described above for SQN Units 1 and 2 UFSAR Section 2.4.3. Additional details including specific changes to the SOCH model analysis are described in Section 2.1 of this enclosure. Table 1 provides a summary of the peak elevations and discharges at TVA dams and SQN produced by the five potential seismically induced dam failure combinations. As shown in Table 1, the peak water surface elevation at SQN from seismically induced dam failures is produced by Seismic Dam Failure Combination H, elevation 708.6 ft.

Table 1 - Summary of Maximum Elevations and Discharges in the Tennessee River Watershed

Location	Parameter	Seismic Dam Failures Combination A	Seismic Dam Failures Combination B	Seismic Dam Failures Combination E	Seismic Dam Failures Combination F	Seismic Dam Failures Combination H
Fort Loudoun Dam	Headwater (feet)	817.2	833.3	817.2	817.2	836.2
	Discharge (cfs)	443,594	2,573,677	383,877	383,877	2,101,716
Tellico Dam	Headwater (feet)	818.5	813.2	818.4	818.4	818.6
	Discharge (cfs)	1,829,012	1,855,019	3,549,639	3,549,639	1,731,678
Melton Hill Dam	Headwater (feet)	817.4	817.0	795.0	795.0	795.0
	Discharge (cfs)	1,053,348	876,224	88,269	88,269	88,275
Watts Bar Dam	Headwater (feet)	763.0	765.6	756.2	756.2	763.1
	Discharge (cfs)	1,074,582	1,195,727	744,786	744,786	1,059,008
Sequoyah Nuclear	Headwater (feet)	706.3	706.0	702.2	706.3	708.6
	Discharge (cfs)	912,939	974,937	775,899	918,880	930,585

These changes represent the most current, complete, and substantiated information relative to the effects of dam failures important to the design and siting of SQN Units 1 and 2 as expected for review by the NRC in SRP Section 2.4.4.

Sections 2.4.5 through 2.4.10

There are no technical changes proposed for these sections requiring NRC review and approval.

Section 2.4.11, Low Water Considerations

The proposed changes to SQN Units 1 and 2 UFSAR Section 2.4.11 update the discussion of low water considerations to reflect the most current information for the hydrologic analysis for SQN Units 1 and 2.

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.11.1, analyses are performed to determine probable minimum water level at SQN Units 1 and 2 and the minimum flow requirement at the ERCW intake. In the proposed change, water level at the SQN site upon failure of the south embankment of Chickamauga Dam resulting in a breach width of 400 ft from an initial Chickamauga Reservoir pool elevation 681.0 ft (slightly below the normal summer pool elevation and the normal summer pool elevation in Nickajack Reservoir) begins to drop in 0.5 hours and reaches elevation 641.0 ft (minimum river elevation for required minimum level in the ERCW intake canal) in 51 hours. These changes are the result of updates to the routing model cross-sectional data using new bathymetry and recalibration of the models, as determined by postulating loss of Chickamauga Dam and no flow from Watts Bar Dam. In the proposed change, flow required to maintain an elevation of 641.0 ft is the same as the original analysis, 14,000 cfs within 12 hours of Chickamauga Dam failure.

These changes represent the most current, complete, and substantiated information relative to the low water effects important to the design and siting of SQN Units 1 and 2 as expected for review by the NRC in SRP Section 2.4.11.

Sections 2.4.12 and 2.4.13

There are no technical changes proposed for these sections requiring NRC review and approval.

Section 2.4.14, Flooding Protection Requirements

The proposed changes to SQN Units 1 and 2 UFSAR Section 2.4.14 and Appendix 2.4A update the discussion of flooding protection requirements to reflect the most current information for the hydrologic analysis for SQN Units 1 and 2. As described in SQN Units 1 and 2 UFSAR Subsection 2.4.14 and Appendix 2.4A, an evaluation is performed to determine the methods by which the SQN is capable of tolerating floods above plant grade without jeopardizing public safety. The DBF is the calculated upper-limit flood that includes the PMF plus the wave runup caused by a 45 mph overland wind as discussed in SQN Units 1 and 2 UFSAR Subsection 2.4.3.6. As a result of the changes to inputs and methodology discussed previously, the DBF elevations at various plant locations that would occur by the limiting large rainfall and seismically induced dam failure floods are increased to the following:

Plant Location	DBF Level (ft.)
Probable Maximum Flood (still reservoir)	722.0
DBF Runup on Diesel Generator Building	723.2
DBF Runup on vertical external, unprotected walls	726.2
DBF Surge level within flooded structures	722.5

SQN is designed in accordance with the Regulatory Position 2 of RG 1.59, Revision 2, August 1977, which specifies that at least those structures, systems, and components necessary for cold shutdown and maintenance thereof are designed with hardened protective features to remain functional while withstanding the entire range of flood conditions up to and including the worst site-related flood probable (e.g., PMF, seismically induced flood, hurricane, surge, seiche, heavy local precipitation) with coincident wind-generated wave action as discussed in Regulatory Position 1 of the RG.

Although the DBF elevations at various plant locations that would occur by the limiting large rainfall and seismically induced dam failure floods are increased from those currently provided in the SQN Units 1 and 2 UFSAR, there are only two distinct changes to the physical flooding protection features of SQN Units 1 and 2 required. The other safety-related systems, structures, and components identified in Regulatory Guide 1.29 are designed to withstand the flood conditions associated with the updated DBF elevations, and would remain functional during external floods.

The UFSAR currently requires the Reactor Building, Diesel Generator Building, and the ERCW Intake Station to remain dry during flood mode. The Reactor Building and ERCW Intake Station remain protected from the updated DBF levels.

The lowest floor of the common SQN Units 1 and 2 Diesel Generator Building is at elevation 722.0 ft with its doors on the uphill side facing away from the main body of flood water. This elevation is lower than the updated DBF level of elevation 723.2 ft. Therefore, flood levels exceed the floor level at elevation 722.0 ft. The entrances into safety-related areas and mechanical and electrical penetrations into safety-related areas are sealed to prevent major leakage into the building for water up to the grade elevation 722.0 ft. Additionally, redundant sump pumps are provided within the building to remove minor leakage. As a result of this increase, staged sandbags to be constructed into a berm at the entrances to the Diesel Generator Building at any time prior to or during the event of a Stage I flood warning has been established as a compensatory measure. These sandbags will be constructed into a berm at least three ft in height (elevation 725.0 ft) to prevent water intrusion inside the building. Permanent plant modifications are planned to provide adequate flooding protection features for the common SQN Units 1 and 2 Diesel Generator Building.

The Service, Turbine, Auxiliary, and Control Buildings are permitted to flood as the water exceeds the plant level entrances. No permanent barriers to specifically protect flood sensitive plant equipment exist in any of these structures except, as discussed further in Section 3.3 of this enclosure, the SQN Units 1 and 2 Spent Fuel Pit Cooling Pump Enclosure caps in the Auxiliary Building are now required to maintain adequate flooding protection of the Spent Fuel Pit Cooling Pump Motors during flood mode. The DBF surge level within flooded structures is elevation 722.5 ft. The Spent Fuel Pit Cooling Pump Motors platform is located at elevation 721.0 ft, but is located in an enclosure that provides flooding protection up to elevation 724.5 ft. However, the Spent Fuel Pit Cooling Pump Enclosure caps were not originally intended to be permanently installed. To restore margin for the Spent Fuel Pit Cooling Pump Motors,

installation of the caps at any time prior to or during the event of a Stage I flood warning has been established as a compensatory measure. A documentation change is planned to require the SQN Units 1 and 2 Spent Fuel Pit Cooling Pump Enclosure caps as a permanent plant feature for flooding protection.

Regulatory Position 2 of RG 1.59, Revision 2, August 1977, also specifies that sufficient warning time is shown to be available to shut the plant down and implement adequate emergency procedures.

TVA RO is responsible for operations of the TVA dams and reservoirs for the Tennessee River watershed, including the controls and scheduling of the releases from flood storage dams above the nuclear sites as an integrated system. The USACE is responsible for operation of the locks on the Tennessee River. TVA RO operates the TVA dams and reservoirs for purposes that include:

- Flood control and storm water management of the Tennessee River and major tributaries,
- Irrigation of land along the Tennessee River,
- Generation of hydroelectric power,
- Cooling of fossil and nuclear power plants,
- Navigation of recreational and commercial vessels,
- Public and industrial water supplies, and
- General recreation of the public.

As a part of TVA RO's flood control responsibilities, forecast and warning procedures have been established that reflect the updated hydrologic analyses. The safety of the plant in extreme events requires shutdown procedures which may take 27 hours to implement. TVA's calculation demonstrates that the time is available for TVA RO's forecast and warning procedures to provide at least 27 hours before river levels reach elevation 703.0 ft. Use of elevation 703.0 ft, 2.0 ft below plant grade, provides enough margin to prevent wind generated waves from endangering plant safety during the final hours of shutdown activity. Flood warning is based upon rainfall already reported to be on the ground on the watershed above SQN. Although the warning time for SQN has been reevaluated, the only significant change in the results of the analysis of warning time is the use of a revised forecasted plant site water levels where Stage I actions are required to begin. Use of these revised Stage I action levels does not reduce the effectiveness of the warning plan, as there is still a minimum of 27 hours to prepare for operation in the flood mode.

The warning time for SQN has been reevaluated because the initial median reservoir levels and flood operational guides have been revised, dam rating curves have changed at some dams, and the SOCH model of the Tennessee River has been updated to meet current quality assurance standards. Details of the warning plan analysis follows:

The design basis PMF event for SQN is based on storms with the heavy rainfall occurring in the middle of the three-day main storm (adopted distribution). This time distribution is supported by

evaluation of actual storm events which have occurred in the region and is consistent with regulatory guidance and accepted practice. In order to address the warning time issue, different time distributions have been evaluated.

The original analysis tested the effects of varied time distribution of rainfall by alternatively placing the maximum daily rainfall on the first, middle, and the last day of the three-day main storm to ensure that the shortest warning times were captured for the hypothetical storms. This analysis showed that the fastest rising floods occur when the heavy rainfall is applied at the end of the storm. The current analysis consists of nine hypothetical storms ranging from slightly more than five inches (equivalent to the largest flood event since regulation) up to PMP and enveloped potentially critical areal, seasonal variations and time distribution of rainfall. The warning time is based on those storm situations which resulted in the shortest time interval between watershed rainfall and elevation 703.0 ft.

The warning time is divided into two stages: Stage I, a minimum of 10 hours long and Stage II, a minimum of 17 hours long so that unnecessary economic consequences can be avoided, while adequate time is allowed for preparing for operation in the flood mode. Stage I allows preparation steps causing minimal economic consequences to be sustained but postpones major economic damage to the plant until a Stage II warning predicts a likely forthcoming flood above plant grade. If the flood does not develop beyond a Stage I warning, major economic damage is avoided.

To be certain of 27 hours for pre-flood preparation, flood warnings with the prospect of reaching elevation 703.0 ft must be issued early when lower threshold flood warning levels are forecast. Consequently, some of the Stage I warnings may not progress into a Stage II warning. For this reason pre-flood preparations are divided into two stages. Stage I steps requiring 10 hours are easily revocable and cause minimum economic consequences to the plant.

Additional rain and stream-flow information obtained during Stage I activity determines if the more serious steps of Stage II need to be taken with the assurance that at least 17 hours is available before elevation 703.0 ft is reached.

Considering results of the original analysis, six storms were identified in the current analysis to envelop the potentially critical variations of rainfall. Separate controlling winter and summer storm events were selected for use with the critical time distribution. The controlling winter event selected was the 21,400 square-mile March downstream centered storm. The controlling summer event selected was the 7,980 square-mile June Bulls Gap centered event. The six selected storms represent average basin rainfall from 5.2 inches up to the PMP. The selected events are described below.

1. 21,400 square-mile March downstream centered PMP storm with heavy rainfall on the last day (HLD)
2. 7,980 square-mile June Bulls Gap centered PMP storm (HLD)
3. 21,400 square-mile March downstream centered PMP storm scaled to 10 inches above Chickamauga Dam, (HLD)
4. 7,980 square-mile June Bulls Gap centered PMP storm scaled to 10 inches above Chickamauga Dam, (HLD)
5. 21,400 square-mile March downstream centered PMP storm scaled to 5.2 inches above Chickamauga Dam, (HLD)

6. 7,980 square-mile June Bulls Gap centered PMP storm scaled to 5.2 inches above Chickamauga Dam, (HLD)

In addition to the six storms above, the three PMF candidate events listed below are analyzed to determine the design basis flood at SQN.

7. 21,400 square-mile, March, downstream centered PMP storm with the adopted distribution
8. 7,980 square-mile, March, Bulls Gap centered PMP storm with the adopted distribution
9. 7,980 square-mile, June, Bulls Gap centered PMP storm with the adopted distribution

For events 7 to 9 listed above, the heavy rainfall is in the middle of the three-day main storm and is referred to as the adopted distribution.

The results of the six simulations performed as part of this analysis, together with the results of the three additional simulations, were used to develop the relationship between basin average rainfall and peak river elevation at SQN.

The maximum calculated water surface elevation at SQN for each storm was plotted against average basin rainfall depth. Summer and winter relationships were developed using a polynomial curve. This approach did not result in curves which passed through each of the calculated points. To ensure that the curve would envelop the calculated points, a systematic adjustment of the polynomial coefficients was applied until the curve passed thru the calculated points or was within 0.1 ft above.

The adopted warning time curves envelop the routing simulation results for their respective seasons using inflows from the selected worst case storm events. Therefore, these curves are a bounding condition for determining the warning times at SQN.

The warning time to assure safe shutdown of SQN for flooding resulting from seismic dam failures coincident with flood events is based upon analysis of potentially critical combinations of dam failures.

Flood warnings are issued in real-time by TVA RO. Flood control operations for a major storm that spans the majority of the Tennessee Valley would necessitate the integrated operation of the reservoirs in the system. The flood storage available to TVA for minimizing flood damages is finite, and does not allow TVA to eliminate flooding at every area along the regulated rivers. Thus, TVA efforts are directed toward using the available flood storage to minimize downstream flooding, rather than eliminating downstream flooding. During extreme flood events, TVA would focus on minimizing downstream flood damage to the extent possible, operating the projects to ensure the safety and integrity of the dams and appurtenant structures, and providing frequent flood warning time and elevation forecasts.

The one-half PMF, developed as part of the seismic flood analysis, addresses item 2 of Regulatory Position 2, Regulatory Guide 1.59, Revision 2. This storm was developed by taking one-half the runoff ordinates of the design basis flood including the antecedent flood (21,400 square-mile PMP storm) plus base flow and routing them through the reservoir system.

Based on use of the warning time methodology described above, a minimum of 27 hours has been allowed for preparation of the plant for operation in flood mode. An additional 4 hours is allowed for communication and forecasting computations by the TVA RO organization to

translate rain on the ground to river elevations at the plant. Hence, the warning time provides a minimum of 31 hours from arrival of rain on the ground until elevation 703.0 ft could be reached. A minimum of 27 hours is allowed for shutdown at the plant which consists of a minimum of 10 hours of Stage I preparation and a minimum of 17 hours for Stage II preparation that is not concurrent with the Stage I activity.

Although reservoir elevation 703.0 ft, 2.0 ft below plant grade to allow for wind waves, is the controlling elevation for determining the need for plant shutdown, lower forecast threshold warning flood elevations are used in some situations to assure that the 27 hours pre-flood transition interval is always available. The threshold warning flood elevations differ with season of the year.

Determination of the warning time and flood elevations at SQN requires the following:

1. The elevation hydrograph at the plant for each simulated rainfall event;
2. A plot of the cumulative storm rainfall for each rainfall event; and
3. The relationship between average basin rainfall and plant elevation.

The shortest warning time scenario for the winter was determined to be produced by the March 21,400 square mile downstream centered PMP with the heavy rainfall on the last day. The shortest warning time for the summer flood was produced by the 7,980 square mile June Bulls Gap centered PMP with the heavy rainfall on the last day.

Inasmuch as the hydrologic procedures and threshold flood warning levels have been established to provide adequate shutdown time in the flood producing the shortest warning time, longer times are available in other floods. In such cases there is a waiting period after the Stage I 10-hour shutdown activity during which activities shall be in abeyance until TVA RO determines, based upon weather conditions, that plant operation can be resumed, or if Stage II shutdown should be implemented.

For rainfall induced floods, the available warning times are adopted as results and have been evaluated for the flood conditions producing the shortest warning time. Therefore, more time would be available in other flood situations. Table 2 includes the predicted threshold flood warning levels for the shortest warning time flood conditions which assure adequate warning time for plant shutdown.

Table 2 – Warning Threshold Flood Warning Levels

	Stage I Shutdown		Stage II Shutdown	
Season	Elevation (ft)	Rainfall* (inches)	Elevation (ft)	Rainfall* (inches)
Winter	694.5	7.4	703.0	9.8
Summer	699.0	8.2	703.0	9.5

* Rainfall in table refers to "inches of rain on the ground above Chickamauga Dam."

For seismically induced dam failure floods, Table 3 provides the maximum elevations and warning times at SQN for the five seismic combinations evaluated. The following four seismic dam failure combinations would result in flood levels above plant grade elevation (705.0 ft).

1. SSE failure of Norris, Cherokee, Douglas and Tellico Dams coincident with the 25-year flood;

2. OBE failure of Norris and Tellico Dams coincident with one-half PMF;
3. OBE failure of Tellico, Hiwassee, Apalachia and Blue Ridge Dams and partial failure of Fontana Dam coincident with one-half PMF, and
4. OBE failure of Cherokee, Douglas, and Tellico Dams coincident with one-half PMF.

As shown in Table 3, the other candidate combination of events would create flood levels below plant grade elevation (705.0 ft). The times from seismic occurrence to arrival of failure surge at the SQN are shown in Table 3. The failure of Tellico, Hiwassee, Apalachia and Blue Ridge Dams and partial failure of Fontana Dam in an OBE event coincident with one-half PMF produces the shortest arrival time at 32 hours and is adequate to permit safe plant shutdown in readiness for flooding.

Dam failure during non-flood periods was not reevaluated, but would be bounded by the four critical failure combinations described above.

The warning time for safe plant shutdown in seismically induced dam failure flood events is based on the fact that a failure combination of critically centered large earthquake conditions must exist before the flood waves from seismically induced dam failures could exceed plant grade.

Table 3 - Floods from Postulated Seismic Failure of Upstream Dams
(Plant Grade is Elevation 705.0 ft)

	SQN Plant Elevation (ft)	Flood Wave Travel Time[c] (hr)
OBE Failure with One-Half Probable Maximum Flood		
Norris – Tellico	706.7	34
Cherokee – Douglas – Tellico	708.6	46
Partial Fontana – Tellico – Hiwassee – Apalachia – Blue Ridge[a]	706.3	32
Partial Fontana – Tellico[a]	702.2	NA
SSE Failure with 25-Year Flood		
Norris – Cherokee – Douglas – Tellico[b]	706.0	53

a. Includes failure of four ALCOA dams and one Duke Energy dam – Nantahala (Duke Energy, formerly ALCOA), upstream; Santeetlah, on a downstream tributary; and Cheoah, Calderwood, and Chilhowee, downstream. Fort Loudoun gates are inoperable in open position.
b. Gate opening at Fort Loudoun prevented by bridge failure.
c. Time from seismic dam failure to arrival of failure wave at SQN elevation 703.0 ft (2.0 ft below plant grade).

For flood conditions resulting from one-half PMF, RG 1.59 specifies that safety-related facilities designed in accordance with Regulatory Position 2 must be designed to withstand the flood conditions resulting from a Standard Project event (defined as flow rates generally 40 percent to 60 percent of the PMF) with attendant wind-generated wave activity that may be produced by the worst winds of record and remain functional.

The one-half PMF (magnitude in range of Regulatory Guide specifications) would produce a maximum elevation at SQN of 701.6 ft. This is 3.4 ft below plant grade elevation 705.0 ft. RG 1.59 specified attendant wind-generated wave activity that may be produced by the worst winds of record would not present a problem due to the short wind fetch lengths (0.23 to

1.54 miles) and the elevation margin of 3.4 ft available to plant grade elevation. The modeling conventions used in this simulation produce conservative results at SQN.

These changes represent the most current, complete, and substantiated information relative to the emergency operations important to the design and siting of SQN Units 1 and 2 as expected for review by the NRC in SRP Section 2.4.14.

As previously stated, the warning time is divided into two stages: Stage I, a minimum of 10 hours long; and Stage II, a minimum of 17 hours long, so that unnecessary economic consequences can be avoided, while adequate time is allowed for preparing for operation in the flood mode. The plant procedure governing preparations for operation in the flood mode includes the following initial assumptions:

1. SQN Units 1 and 2 is at 100% power.

2. Stage I Flood Warning is issued by TVA RO at the threshold flood warning levels during the "winter" season of elevation 694.5 ft, or during the "summer" season of elevation 699.0 ft.

Upon issuance of the Stage I Flood Warning, the following actions are taken in accordance with the appropriate procedures:

1. A "Notification of Unusual Event" would be declared per the Emergency Plan, and support staffing of the Technical Support Center would be initiated.

2. Shutdown to Mode 3 (Hot Standby) would be commenced using AOP-C.03, Rapid Shutdown.

3. Cooldown of the Reactor Coolant System (RCS) to Mode 4 (less than 350°F) by dumping steam and then placing Residual Heat Removal (RHR) Shutdown Cooling in service would be performed.

4. The RCS would be borated to maintain shutdown margin.

5. Preparations would be made to place the Auxiliary Charging/Flood Mode Boration System in service.

6. Various other preparations would be completed such as moving necessary supplies above the maximum flood elevation and filling tanks to prevent floating.

Upon issuance of the Stage II Flood Warning or if RO confirms that elevation 703.0 ft is likely to be exceeded, the following actions are taken in accordance with the appropriate procedures:

1. An "Alert" would be declared per the Emergency Plan.

2. If off-site power is still supplying the shutdown boards, then the shutdown boards would be manually transferred to the diesel generators.

3. Auxiliary Feedwater pumps would be stopped and High Pressure Fire Protection water to the steam generators would be established, including aligning valves and installation of spool pieces. This requires steam generator pressure less than 90 psig.

4. When decay heat removal is established by High Pressure Fire Protection water to the steam generators, RHR Shutdown Cooling would be removed from service.

5. Other spool pieces would be installed to establish ERCW cooling to Spent Fuel Pit Cooling heat exchangers and reactor coolant pump thermal barriers.

6. Heat sink would be maintained by releasing steam via steam generator atmospheric relief valves with secondary makeup water supplied by High Pressure Fire Protection.

7. RCS inventory would be maintained using Auxiliary Charging pumps.

8. RCS pressure would be maintained less than 500 psig with RCS temperature less than 328°F to assure that Fire/Flood Mode pumps can supply High Pressure Fire Protection to steam generators.

Flood mode operation would continue until conditions as described in the appropriate plant procedures allow either further plant cooldown or restart.

3.2 *Uncertainties*

As stated in RG 1.59, Revision 2, Probable Maximum Water Level is defined by the Corps of Engineers as "the maximum still water level (i.e., exclusive of local coincident wave runup) which can be produced by the most severe combination of hydrometeorological and/or seismic parameters reasonably possible for a particular location. Such phenomena are hurricanes, moving squall lines, other cyclonic meteorological events, tsunami, etc., which, when combined with the physical response of a body of water and severe ambient hydrological conditions, would produce a still water level that has virtually no risk of being exceeded." The PMF for streams and rivers for sites like SQN Units 1 and 2 is the hypothetical flood (peak discharge, volume, and hydrograph shape) that is considered to be the most severe, reasonably possible, based on comprehensive hydrometeorological application of PMP and other hydrologic factors favorable for maximum flood runoff such as sequential storms and snowmelt. The primary standards followed for development of the PMF are American National Standards Institute/American Nuclear Society (ANSI/ANS) 2.8 and RG 1.59, Revision 2. These guidance documents state that the PMF be derived from the combination of circumstances that collectively represent a risk probability that is acceptable for nuclear plant accidents. Each element in the development of the PMF is based on best available data including PMP estimates from the National Weather Service, rain-runoff relationships developed from historical storms, time distribution of PMP consistent with storms in the region, seasonal and areal considerations of rainfall, current reservoir operations, and verification of runoff and stream course models against large historic floods. Per ANSI/ANS 2.8 and RG 1.59, the techniques applicable to PMF and seismically induced floods for nuclear power plants are estimates. The calculations which support the PMF analysis document assumptions and approaches which are consistent with ANSI/ANS 2.8 and RG 1.59. The PMF analysis is a best estimate and is consistent with these standards and guidelines. However, it is realized that various elements of the analysis when modified result in different elevations, some higher and some lower, and those elements discussed in further detail below are consistent with these standards and guidelines demonstrating that the PMF analysis is a reasonable best estimate.

EVALUATION OF PROPOSED CHANGES

As discussed in NUREG/CR-7046, "Design-Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America," the appropriate method to address the uncertainty in the hydrologic analysis is through calibration of the model to historic flood events or sensitivity analyses. TVA calibrated the model to historic flood events using the two highest recent flood events where data exists. The floods used for calibration are March 1973 and May 2003 with elevations at SQN of approximately 687.0 ft and 687.8 ft for those two storms. In addition to the calibration using historic data, sensitivity analyses for the Bellefonte model have been completed. While the input assumptions regarding failure of Chickamauga Dam and the Chickamauga Dam spillway gate configurations differ between the two models, insights may be applied to SQN based on these sensitivity analyses. The rainfall-to-runoff transformation (unit hydrographs) is completed. The unit hydrographs are peaked by 25% and the results show that the model is not sensitive to this parameter.

The rainfall loss rate is another parameter that has been evaluated. TVA uses the Antecedent Precipitation Index rain-runoff relationship. This is the same methodology used by TVA for the daily reservoir operations. This parameter does show sensitivity to the model resulting in several feet added to the PMF elevation when increasing the runoff from 89% to 100%. Much of this increase was caused by over-topping failure of dams above SQN. However, the rainfall loss rate used in the TVA model is a realistic value for TVA based on regional historic data over more than 60 years, and there is high confidence in this value as the appropriate value for hydrology modeling. In addition, this parameter was evaluated by comparison to other acceptable methods for determining rain-runoff relationships discussed in NUREG/CR-7046. The methodology used by TVA is conservative when compared to the other acceptable methods.

Other parameters in the stream course model such as the Manning's n value or resistance to flow could be increased or decreased during extreme flood events such as the PMF. The adopted values in the model are based on calibration against two of the largest floods of record. If it is postulated that debris in the overbanks would result in an increase in resistance to flow and thus an increase in the Manning's n values, then the elevation at SQN would increase. If it is postulated that Manning's n values would be decreased, then the elevations at SQN would be decreased. Such decreases have been documented for large flood events on the Mississippi River and could have been considered in the updated hydrologic analysis, but Manning's n values were conservatively not decreased. Based on this documented experience, there is conservatism in the applied Manning's n values but it is difficult to quantify since the flood has never been out of channel to the extreme that it would be in the PMF.

Therefore, TVA uses the best estimate approach with calibration to the two largest recorded floods with data.

Dam rating curves are developed assuming that gates will be open, and TVA RO has committed to making this occur during the PMF event. For the flood simulations, the spillway gates are operated when and as needed for flood regulation up to and including the fully open position. The model has not been tested for loss of gate capacity although it may be assumed that loss of gate capacity could result in an increase in PMF elevation. However, quantification of the change is not easily determined.

While not tested during sensitivity analyses, it is known that a conservative assumption is made regarding the downstream dam, Chickamauga Dam. This dam is overtopped during the PMF but is assumed to not fail.

Finally, the TVA hydrology model has been reviewed by an expert panel and the panel agreed that due to the complexity of the system, it would be very difficult to highlight conservatisms in the model. The panel concluded after review that the analysis was rigorous and technically sound. Based on this discussion, the hydrologic analysis is considered to be a reasonable best estimate that has accounted for uncertainties based on regulatory guidance using the best data available.

3.3 Margins

As previously discussed in the TVA submittal to the NRC Document Control Desk, "Commitments Related to Updated Hydrologic Analysis Results for Sequoyah Nuclear Plant, Units 1 and 2, and Watts Bar Nuclear Plant, Unit 1," dated June 13, 2012 (ADAMS Accession No. ML12171A053), the limiting safety-related components required to be available during a plant flood affected by the increase in DBF elevations are the Spent Fuel Pit Cooling Pump Motors and applicable equipment required for flood mode operation located in the Diesel Generator Building. To restore margin for the Spent Fuel Pit Cooling Pump Motors, installation of the Spent Fuel Pit Cooling Pump Enclosure caps at any time prior to or during the event of a Stage I flood warning has been established as a compensatory measure. For the Diesel Generator Building, staged sandbags to be constructed into a berm at any time prior to or during the event of a Stage I flood warning has been established as a compensatory measure. As committed to in the June 13, 2012 submittal, TVA will implement a documentation change to require the Spent Fuel Pit Cooling Pump Enclosure caps as a permanent plant feature for flooding protection, and will install permanent plant modifications to provide adequate flooding protection with respect to the DBF level for the Diesel Generator Building, by March 31, 2013.

3.4 Conclusions

The revised DBF elevations at the SQN Units 1 and 2 site are determined to impact some of the safety-related systems, structures, or components required to be available during a plant flood. However, temporary compensatory measures are in place to ensure adequate flooding protection if a PMF event were to occur. Except for the limited cases of the Spent Fuel Pit Cooling Pump Motors and applicable equipment required for flood mode operation located in the Diesel Generator Building, no physical change to the systems, structures, or components is necessary to ensure that they remain adequately protected from the effects of external floods. Documentation changes and permanent plant modifications are planned to restore or gain additional margin between the revised DBF elevations and limiting safety-related systems, structures, and components. Also, the warning time for SQN shows that there is sufficient time available in both rainfall and seismically induced dam failure floods for safe plant shutdown. In addition, the updated low water level analysis demonstrates that there is sufficient flow to support operation of SQN Units 1 and 2. Although there are numerous changes to inputs for the hydrological analysis, the cumulative effects of these changes do not impact the original conclusions of the SQN Units 1 and 2 UFSAR that adequate flooding protection features and procedures are in place. The hydrologic analysis is considered to be a reasonable best estimate that has accounted for uncertainties based on regulatory guidance using the best data available. The updated hydrologic analysis shows that the design and siting of SQN Units 1 and 2 is adequate to meet the regulatory requirements and criteria specified to be addressed for SQN Units 1 and 2 UFSAR Section 2.4 and that SQN Units 1 and 2 are capable of tolerating floods above plant grade in a manner that does not jeopardize public health and safety.

4.0 REGULATORY EVALUATION

4.1 Applicable Regulatory Requirements and Criteria

10 CFR Part 100, requires identifying and evaluating hydrologic features of the site.

10 CFR 100.23(d) sets forth the criteria to determine the siting factors for plant design bases with respect to seismically induced floods and water waves at the site.

10 CFR 50, Appendix A, General Design Criteria (GDC) 2, requires consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

10 CFR 50, Appendix A, GDC 44, requires providing an ultimate heat sink for normal operating and accident conditions.

In addition to regulatory requirements, acceptable guidance for hydrologic analysis of the site is included in the following:

- Regulatory Guide 1.27 describes the applicable ultimate heat sink capabilities.
- Regulatory Guide 1.29 identifies seismic design bases for safety-related SSCs.
- Regulatory Guide 1.59, as supplemented by best current practices, provides guidance for developing the hydrometeorological design bases.
- Regulatory Guide 1.102 describes acceptable flooding protection to prevent the safety-related facilities from being adversely affected.

The SQN Units 1 and 2 hydrologic analysis conforms to the above regulatory requirements and guidance, using the most recent data and updated methodology which includes use of USACE HEC-HMS and USACE HEC-RAS software.

The SQN Units 1 and 2 hydrologic analysis as described in this License Amendment Request, and as presented in the proposed revision of the SQN Units 1 and 2 UFSAR, contains sufficient substantiated information pertaining to the hydrologic description at the proposed site. The hydrologic analysis meets the requirements of 10 CFR 100 as it relates to:

1. Identifying and evaluating the hydrology in the vicinity of the site and site regions, including interface of the plant with the hydrosphere,
2. Hydrological causing mechanisms,
3. Surface and ground water uses,
4. Spatial and temporal data sets,
5. Alternate conceptual models of site hydrology,

6. Identification and consideration of local intense precipitation and flooding at the site,

7. Identification and consideration of the probable maximum flooding on streams and rivers at the site and in the surrounding area,

8. Identification and consideration of the effects of dam failures at the site and in the surrounding area,

9. Low water effects important to the design and siting of this plant, and

10. The appropriate site phenomena in establishing emergency operations for SSCs important to safety.

Further, the hydrologic analysis considers the most severe natural phenomena that have been historically reported for the site and surrounding area while describing the hydrologic interface of the plant with the site, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

The NRC staff has generally accepted the methodologies used to determine the severity of the phenomena, the local intense precipitation, flooding causal mechanisms, controlling flooding mechanism reflected in these site characteristics, the probable maximum flooding on streams and rivers, the effects of dam failures, the potential for low water conditions, and consideration of the appropriate site phenomena in establishing emergency operations for SSCs important to safety, as documented in safety evaluation reports for previous licensing actions. Accordingly, the use of these methodologies results in site characteristics and procedures containing sufficient margin for the limited accuracy, quantity, and period of time in which the data have been accumulated. In view of the above, the site characteristics previously identified as described in the proposed changes to the SQN Units 1 and 2 UFSAR are acceptable for use in establishing the design bases for SSCs important to safety and site procedures.

4.2 Precedent

TVA evaluated license amendment requests and requests for issuance of Combined Operating Licenses in which the NRC had reviewed and approved changes to or initial hydrologic analysis for existing and proposed new nuclear power plants. Although there are similar requests for various changes to the hydrologic analysis or for a new hydrologic analysis for these other nuclear power plants, no precedent was identified for a rebaselining of an existing hydrologic analysis similar to this request.

4.3 Significant Hazards Consideration

The proposed changes modify SQN Units 1 and 2 UFSAR hydrologic analysis and results, including the DBF elevations required to be considered in the flooding protection of safety-related systems, structures, or components during external flooding events, and verify the adequacy of the warning time for SQN for both rainfall and seismically induced dam failure floods. The proposed changes do not alter the conclusions presented in the SQN Units 1 and 2 UFSAR that equipment required for operation in the flood mode is either above the DBF or suitable for submerged operation considering the temporary compensatory measures in place and upon completion of planned documentation changes and permanent plant

modifications, and that there is sufficient time available in both rainfall and seismically induced dam failure floods for safe plant shutdown. No physical changes to safety-related systems, structures, or components, or any credited flooding protection feature, are required to ensure that they remain adequately protected from the effects of external floods except for the limited cases of the Spent Fuel Pit Cooling Pump Motors and applicable equipment required for flood mode operation located in the Diesel Generator Building. However, temporary compensatory measures are in place to ensure adequate flooding protection if a PMF event were to occur, and documentation changes and permanent plant modifications are planned to restore or gain additional margin between the revised DBF elevations and limiting safety-related SSCs.

TVA has concluded that the changes to SQN Units 1 and 2 UFSAR do not involve a significant hazards consideration. TVA's conclusion is based on its evaluation in accordance with 10 CFR 50.91(a)(1) of the three standards set forth in 10 CFR 50.92, "Issuance of Amendment," as discussed below:

1. Does the proposed amendment involve a significant increase in the probability or consequence of an accident previously evaluated?

   Response: No

   Although the proposed changes require some documentation and physical changes to plant systems, structures, or components to add flooding protection features to restore or gain additional margin between the revised DBF elevations and limiting safety-related systems, structures, and components; implementation of these changes does not 1) prevent the safety function of any safety-related system, structure, or component during an external flood; 2) alter, degrade, or prevent action described or assumed in any accident described in the SQN Units 1 and 2 UFSAR from being performed since the safety-related systems, structures, or components remain adequately protected from the effects of external floods; 3) alter any assumptions previously made in evaluating radiological consequences; or 4) affect the integrity of any fission product barrier.

   Therefore, this proposed amendment does not involve a significant increase in the probability or consequences of an accident previously evaluated.

2. Does the proposed amendment create the possibility of a new or different kind of accident from any accident previously evaluated?

   Response: No.

   The proposed changes do not introduce any new accident causal mechanisms, nor do they impact any plant systems that are potential accident initiators.

   Therefore, the proposed amendment does not create the possibility of a new or different kind of accident from any accident previously evaluated.

3. Does the proposed amendment involve a significant reduction in a margin of safety?

   Response: No.

   The proposed changes do not alter the permanent plant design, including instrument set points, that is the basis of the assumptions contained in the safety analyses. However, documentation changes and permanent plant modifications are planned to restore or gain additional margin between the revised DBF elevations and limiting safety-related systems, structures, and components. Although the results of the updated hydrologic analysis increase the DBF elevations required to be considered in the flooding protection of safety-related systems, structures, or components during external flooding events, the proposed changes do not prevent any safety-related SSCs from performing their required functions during an external flood considering the temporary compensatory measures in place and upon completion of planned documentation changes and permanent plant modifications. Consistent with existing regulatory guidance, including regulatory recommendations and discussions regarding calibration of hydrology models using historical flood data and consideration of sensitivity analyses, the hydrologic analysis is considered to be a reasonable best estimate that has accounted for uncertainties using the best data available.

   Therefore, the proposed changes do not involve a significant reduction in a margin of safety.

4.4 Conclusions

In conclusion, based on the considerations discussed above, (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public.

5.0 ENVIRONMENTAL CONSIDERATION

A review has determined that the proposed amendment would not change a requirement with respect to installation or use of a facility component located within the restricted area, as defined in 10 CFR 20, or would change an inspection or surveillance requirement. Also, the proposed amendment does not involve (i) a significant hazards consideration, (ii) a significant change in the types or significant increase in the amounts of any effluents that may be released offsite, or (iii) a significant increase in individual or cumulative occupational radiation exposure. Accordingly, the proposed amendment meets the eligibility criterion for categorical exclusion set forth in 10 CFR 51.22(c)(9). Therefore, pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the proposed amendment.