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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

July 29, 2016

Mr. Joseph W. Shea
Vice President, Nuclear Licensing
Tennessee Valley Authority
1101 Market Street, LP 3R-C
Chattanooga, TN 37402-2801

SUBJECT: WATTS BAR NUCLEAR PLANT, UNIT 1 – ISSUANCE OF AMENDMENT REGARDING REVISED TECHNICAL SPECIFICATION 4.2.1 "FUEL ASSEMBLIES" TO INCREASE THE MAXIMUM NUMBER OF TRITIUM PRODUCING BURNABLE ABSORBER RODS (CAC NO. MF6050)

Dear Mr. Shea:

The U.S. Nuclear Regulatory Commission (NRC) has issued the enclosed Amendment No. 107 to Facility Operating License No. NPF-90 for the Watts Bar Nuclear Plant, Unit 1. This amendment consists of changes to the license in response to your application dated March 31, 2015, as supplemented by letters dated April 28, May 27, June 15, September 14, September 25, November 30, December 22, and December 29, 2015, and February 22 and March 31, 2016.

The amendment changes Technical Specification (TS) 4.2.1, "Fuel Assemblies"; TS 3.5.1, "Accumulators," Surveillance Requirement (SR) 3.5.1.4; and TS 3.5.4, "Refueling Water Storage Tank (RWST)," SR 3.5.4.3, in order to increase the maximum number of tritium producing burnable absorber rods and to delete outdated information related to the tritium production program.

Enclosure 3 transmitted herewith contains sensitive unclassified information
When separated from Enclosure 3, this document is decontrolled.

The NRC staff has determined that its safety evaluation (SE) tor the subject amendment contains proprietary information pursuant to Title 10 of the *Code of Federal Regulations*, Section 2.390. Accordingly, the NRC staff has prepared a redacted, publicly available, non-proprietary version of the SE. Both versions of the SE are enclosed. Notice of Issuance will be included in the Commission's *Federal Register* notice.

If you have any questions regarding this letter, please contact me at (301) 415-1349.

Sincerely,

Jeanne Dion, Project Manager
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-390

Enclosures:
1. Amendment No. 107 to NPF-90
2. Non-Proprietary Safety Evaluation
3. Proprietary Safety Evaluation

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

TENNESSEE VALLEY AUTHORITY

DOCKET NO. 50-390

WATTS BAR NUCLEAR PLANT, UNIT 1

AMENDMENT TO FACILITY OPERATING LICENSE

Amendment No. 107
License No. NPF-90

1. The U.S. Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for amendment by the Tennessee Valley Authority (TVA or the licensee) dated March 31, 2015, as supplemented by letters dated April 28, 2015, May 27, 2015, June 15, 2015, September 14, 2015, September 25, 2015, November 30, 2015, December 22, 2015, December 29, 2015, February 22, 2016, and March 31, 2016 complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's rules and regulations set forth in Title 10 of the *Code of Federal Regulations* (10 CFR) Chapter I;

   B. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   D. The issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, the license is amended by changes to the Operating License and Technical Specifications as indicated in the attachment to this license amendment, and paragraph 2.C.(2) of Facility Operating License No. NPF-90 is hereby amended to read as follows:

   (2) <u>Technical Specifications and Environmental Protection Plan</u>

   The Technical Specifications contained in Appendix A as revised through Amendment No. 107 and the Environmental Protection Plan contained in Appendix B, both of which are attached hereto, are hereby incorporated into this license. TVA shall operate the facility in accordance with the Technical Specifications and the Environmental Protection Plan.

3. In addition, the license is amended by the addition of a new license condition 2.C.(11) to Facility Operating License No. NPF-90, which is hereby amended to read as follows:

   (11) The licensee shall replace the WBN, Unit 1 upper compartment cooler cooling coils with safety-related cooling coils to eliminate a potential source of containment sump dilution during design basis events prior to increasing the number of Tritium Producing Burnable Absorber Rods (TPBARs) loaded in the reactor core above 704.

4. This license amendment is effective as of the date of its issuance, and shall be implemented within 30 days of issuance.

FOR THE NUCLEAR REGULATORY COMMISSION

Tracy J. Orf, Acting Chief
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Attachment:
Changes to the Operating License
and Technical Specifications

Date of Issuance: July 29, 2016

ATTACHMENT TO LICENSE AMENDMENT NO. 107

FACILITY OPERATING LICENSE NO. NPF-90

DOCKET NO. 50-390

Replace the following page of Facility Operating License NPF-90 with the attached revised pages. The revised pages are identified by amendment number and contains a marginal lines indicating the area of change.

Facility Operating License

REMOVE	INSERT
3	3
4b	4b

Replace the following pages of the Appendix A Technical Specifications with the attached revised pages. The revised pages are identified by amendment number and contain marginal lines indicating the areas of change.

Technical Specification

REMOVE	INSERT
TS 3.5-2	TS 3.5-2
TS 3.5-10	TS 3.5-10
TS 4.0-1	TS 4.0-1

(4) TVA, pursuant to the Act and 10 CFR Parts 30, 40 and 70, to receive, possess, and use in amounts as required, any byproduct, source or special nuclear material without restriction to chemical or physical form, for sample analysis, instrument calibration, or other activity associated with radioactive apparatus or components; and

(5) TVA, pursuant to the Act and 10 CFR Parts 30, 40 and 70, to possess, but not separate, such byproduct and special nuclear materials as may be produced by the operation of the facility.

C. This license shall be deemed to contain and is subject to the conditions specified in the Commission's regulations set forth in 10 CFR Chapter I and is subject to all applicable provisions of the Act and to the rules, regulations, and orders of the Commission now or hereafter in effect, and is subject to the additional conditions specified or incorporated below.

(1) Maximum Power Level

TVA is authorized to operate the facility at reactor core power levels not in excess of 3459 megawatts thermal.

(2) Technical Specifications and Environmental Protection Plan

The Technical Specifications contained in Appendix A as revised through Amendment No. 107 and the Environmental Protection Plan contained in Appendix B, both of which are attached hereto, are hereby incorporated into this license. TVA shall operate the facility in accordance with the Technical Specifications and the Environmental Protection Plan.

(3) Safety Parameter Display System (SPDS) (Section 18.2 of SER Supplements 5 and 15)

Prior to startup following the first refueling outage, TVA shall accomplish the necessary activities, provide acceptable responses, and implement all proposed corrective actions related to having the Watts Bar Unit 1 SPDS operational.

(4) Vehicle Bomb Control Program (Section 13.6.9 of SSER 20)

During the period of the exemption granted in paragraph 2.D.(3) of this license, in implementing the power ascension phase of the approved initial test program, TVA shall not exceed 50% power until the requirements of 10 CFR 73.55(c)(7) and (8) are fully implemented. TVA shall submit a letter under oath or affirmation when the requirements of 73.55(c)(7) and (8) have been fully implemented.

(10) By May 31, 2018, TVA shall ensure that a listing organization acceptable to the NRC (as the Authority Having Jurisdiction) determines that the fire detection monitoring panel in the main control room either meets the appropriate designated standards or has been tested and found suitable for the specified purpose.

(11) The licensee shall replace the WBN, Unit 1 upper compartment cooler cooling coils with safety-related cooling coils to eliminate a potential source of containment sump dilution during design basis events prior to increasing the number of Tritium Producing Burnable Absorber Rods (TPBARs) loaded in the reactor core above 704.

D. The following exemptions are authorized by law, will not present an undue risk to the public health and safety, and are consistent with the common defense and security. Therefore, these exemptions are granted pursuant to 10 CFR 50.12.

(1) Deleted

SURVEILLANCE REQUIREMENTS

	SURVEILLANCE	FREQUENCY
SR 3.5.1.1	Verify each accumulator isolation valve is fully open.	12 hours
SR 3.5.1.2	Verify borated water volume in each accumulator is ≥ 7630 gallons and ≤ 8000 gallons.	12 hours
SR 3.5.1.3	Verify nitrogen cover pressure in each accumulator is ≥ 610 psig and ≤ 660 psig	12 hours
SR 3.5.1.4	Verify boron concentration in each accumulator is ≥ 3000 ppm and ≤ 3300 ppm.	31 days AND -------NOTE ----------- Only required to be performed for affected accumulators. --------------------------- Once within 6 hours after each solution volume increase of ≥ 75 gallons, that is not the result of addition from the refueling water storage tank.

(continued)

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.5.4.1	------------------------------NOTE--------------------------------- Only required to be performed when ambient air temperature is < 60°F or > 105°F. --- Verify RWST borated water temperature is ≥ 60°F and ≤ 105°F.	24 hours
SR 3.5.4.2	Verify RWST borated water volume is ≥ 370,000 gallons.	7 days
SR 3.5.4.3	Verify boron concentration in the RWST is ≥ 3100 ppm and ≤ 3300 ppm	7 days

4.0 DESIGN FEATURES

4.1 Site

4.1.1 Site and Exclusion Area Boundaries

The site and exclusion area boundaries shall be as shown in Figure 4.1-1.

4.1.2 Low Population Zone (LPZ)

The LPZ shall be as shown in Figure 4.1-2 (within the 3-mile circle).

4.2 Reactor Core

4.2.1 Fuel Assemblies

The reactor shall contain 193 fuel assemblies. Each assembly shall consist of a matrix of Zircalloy or Zirlo fuel rods with an initial composition of natural or slightly enriched uranium dioxide (UO_2) as fuel material. Limited substitutions of zirconium alloy or stainless steel filler rods for fuel rods, in accordance with approved applications of fuel rod configurations, may be used. Fuel assemblies shall be limited to those fuel designs that have been analyzed with applicable NRC staff approved codes and methods and shown by tests or analyses to comply with all fuel safety design bases. A limited number of lead test assemblies that have not completed representative testing may be placed in nonlimiting core regions. For Unit 1 Watts Bar is authorized to place a maximum of 1792 Tritium Producing Burnable Absorber Rods into the reactor in an operating cycle.

4.2.2 Control Rod Assemblies

The reactor core shall contain 57 control rod assemblies. The control material shall be either silver-indium-cadmium or boron carbide with silver indium cadmium tips as approved by the NRC.

(continued)

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 107 TO FACILITY OPERATING LICENSE NO. NPF-90

TENNESSEE VALLEY AUTHORITY

WATTS BAR NUCLEAR PLANT, UNIT 1

DOCKET NO. 50-390

This document contains redacts proprietary information pursuant to
Title 10 of the *Code of Federal Regulations* (10 CFR) Section 2.390.
Redacted information is identified by blank text within double brackets as shown here [[ ]].

1.0 INTRODUCTION

By application dated March 31, 2015 (Reference 1), as supplemented by letters dated

- April 28, 2015 (Reference 2)
- May 27, 2015 (Reference 3)
- June 15, 2015 (Reference 4)
- September 14, 2015 (Reference 5)
- September 25, 2015 (Reference 6)
- November 30, 2015 (Reference 7)
- December 22, 2015 (Reference 8)
- December 29, 2015 (Reference 9)
- February 22, 2016 (Reference 10) and
- March 31, 2016 (Reference 11)

the Tennessee Valley Authority (TVA or the licensee) submitted a License Amendment Request (LAR) to change the Technical Specifications (TSs) for the Watts Bar Nuclear Plant (WBN), Unit 1. The proposed TS change would increase the maximum allowable number of tritium producing burnable absorber rods (TPBARs) in the reactor core from 704 to 1,792. The proposed TS Surveillance Requirement (SR) changes would remove outdated information. The March 31, 2015 submittal included an Enclosure with updated information regarding the environmental impacts associated with tritium production (Reference 1). The supplement dated April 28, 2015 (Reference 2) corrected a typographical error in the March 31, 2015 submittal. The supplements dated May 27, and June 15, 2015 (References 3 and 4) provided information requested during the acceptance review.

The supplement dated September 14, 2015 (Reference 5) provided responses to a request for additional information (RAI) from the Reactor Systems Review Branch. The supplement dated September 25, 2015 (Reference 6) provided responses to RAIs from the Radiation Protection

Enclosure 2

and Consequence Branch (ARCB). The supplement dated November 30, 2015 (Reference 7) provided responses to RAIs from the Nuclear Performance and Code Review Branch. The U.S. Nuclear Regulatory Commission (NRC) conducted an audit of lithium leach rate test and TPBAR burst test documentation at the Pacific Northwest National Laboratory (PNNL) on November 3 and 4, 2015. As a result of the audit, the staff requested additional information regarding the licensee's assumptions for the TPBAR burst test methodology; the licensee provided the information by letter dated December 29, 2015 (Reference 9).

The supplements dated December 22, 2015 and February 22, 2016 (References 8 and 10) responded to subsequent RAIs from ARCB staff. During a public meeting held on February 5, 2016, TVA informed the NRC that it would revise the response to ARCB RAI 1.b. The revised RAI response (Reference 10) included a commitment to revise RCI-137, "Radiation Production Tritium Control Program," Table 3.1, "Tritium Action Levels," to incorporate criteria from NRC Regulatory Guide (RG) 8.32, "Criteria for Establishing a Tritium Bioassay Program." The supplement dated March 31, 2016 (Reference 11) provided revised responses to ARCB RAIs 3, 4, and 6. Enclosure 2 of Reference 11 provided a revised version of "Review of the Radiological and Environmental Considerations for Production of Tritium at WBN Unit 1 – 1,792 TPBAR Core," and supersedes the information previously provided in Enclosure 2 of Reference 1 and Reference 4.

In Enclosure 6 of Reference 11, the licensee provided an updated list of Regulatory Commitments that supersedes the previous commitment lists provided in References 1, 5, 8, and 10. In References 1, 5, 8, and 10, TVA committed to replace containment isolation thermal relief check valves on the WBN Unit 1 Component Cooling System (CCS) and Essential Raw Cooling Water (ERCW) System (Commitment 1). In Reference 11, TVA confirmed that the replacement of the subject thermal relief check valves had occurred. Therefore, Commitment 1 was deleted from the Commitment List (Enclosure 6 of Reference 11).

Enclosure 5 of Reference 11 contains a proposed license condition requiring replacement of the WBN Unit 1 upper compartment cooler cooling coils before TPBAR loading can be increased past 704 TPBARs per core. This condition would be 2.C.(11) in the amended Facility Operating License.

The supplements in References 5 - 11 provided additional information that clarified the application and did not expand the scope of the application as originally noticed in the *Federal Register* (FR) on July 7, 2015 (80 FR 38752).

A correction to the FR notice was published on April 22, 2016 (81 FR 23761) to add the April 28, 2015, submittal to the list of references of the original notice.

2.0 REGULATORY EVALUATION

2.1 Background on TPBAR loading at WBN Unit 1 and relevant license amendments

The U.S. Department of Energy (DOE) has chosen TVA's WBN Unit 1 to produce tritium for the replenishment of the National Security Stockpile by irradiating TPBARs installed in the core. TPBARs are similar to standard burnable poison rod assemblies (BPRAs) inserted into fuel assemblies. The BPRAs absorb excess neutrons, and help control the power in the reactor to ensure an even power distribution and extend the time between refueling outages. TPBARs function in a matter similar to a BPRA, but TPBARs absorb neutrons using lithium aluminate instead of boron. Tritium is produced when the neutrons strike the lithium material. A solid zirconium material in the TPBAR, called a getter, captures the tritium as it is produced. Most of the tritium is trapped in the getter material. However, a small fraction of the tritium will permeate through the TPBAR cladding into the reactor coolant system (RCS). After one cycle of exposure, the TPBARs are removed from the fuel assemblies and shipped to a DOE extraction facility.

NRC reviewed DOE's safety assessments submitted in its "Tritium Production Core Topical Report," NPD-98-181 dated July 30, 1998 and revision submitted by letter dated February 10, 1999 (Reference 12). DOE's topical report assessed how inserting 3,300 TPBARs into the reactor core of a typical large nuclear power plant would affect it. NRC staff reviewed the topical report and issued a safety evaluation (SE) in May 1999, NUREG-1672, "Safety Evaluation Report Related to the Department of Energy's Topical Report of the Tritium Production Core" (Reference 13). NUREG-1672 represents the staff's generic acceptance of resolution of the technical issues with TPBAR loading cores except the identified plant-specific issues and any emergent issues that may not have been considered. The staff's review of the current LAR is focused on plant-specific changes or new TPBAR-related information. Any changes from previously approved designs or methodology or any new relevant information are discussed in this SE, and the remainder of the staff's previous SE in NUREG-1672 remains applicable.

Amendment No. 40 to the WBN Unit 1 Operating License was issued September 23, 2002, and authorized the insertion of up to 2304 TPBARs in the WBN Unit 1 core (Reference 14). The NRC staff performed an Environmental Assessment and Finding of No Significant Impact published in the FR on August 26, 2002 (67 FR 54826) and available at NRC's Agencywide Documents Access and Management System (ADAMS) Accession No. ML022320905.

Because of issues related to the reactor coolant boron concentration, and a higher than expected permeability of tritium from the TPBARs, the licensee reduced the number of TPBARs to be irradiated to 240 in Cycle 6. Amendment No. 48 was issued on October 8, 2003, and authorized the irradiation of 240 TPBARs in the WBN Unit 1 core (Reference 15). Based on issues related to credit for control rod insertion during a cold leg loss-of-coolant-accident (LOCA) and containment sump boron concentration, TVA noted that the number of TPBARs to be irradiated would be limited to 240 instead of the previously approved limit of 2304.

Design changes were made to the TPBARs for Cycle 9 and resulted in a TVA request to increase the number of TPBARs to be irradiated to 400. Amendment No. 67 was issued on January 18, 2008, and authorized the irradiation of 400 TPBARs in the WBN Unit 1 core (Reference 17).

Amendment No. 77 (Reference 18) was issued on May 4, 2009, and approved an increase in the maximum number of TPBARs that can be irradiated from 400 to 704. This limit reflected the average tritium permeation experienced during TPBAR operations in Cycles 6 through 8, and the number of TPBARs that could be loaded without exceeding the original design basis source term of 2,304 Curies per year (Ci/year) attributable to TPBARs.

Because permeation rates in Cycles 6 through 9 were shown to be consistent, the number of TPBARs irradiated in Cycles 11 and 12 were increased to 544. During Cycles 13 and 14, TVA loaded the maximum 704 TPBARs in the WBN Unit 1 core. The permeation issue is described in the licensee's March 31, 2016, RAI response (Reference 11) and is addressed by the NRC staff further in Section 3.5.

Amendment No. 51 (Reference 16) was issued March 29, 2004, and approved manual isolation of valves in the ERCW system and the CCS to include the use of operator actions in certain postulated events (Reference 16). The proposed amendment includes replacing certain valves with passive relief valves and would return the plant configuration to the pre-Amendment No. 51 design basis. Section 3.3 discusses the human factors review pertinent to the elimination of manual operator actions.

Amendment No. 91 was approved on December 5, 2013, and approved changes in dose equivalent iodine-131 (I-131) Spike limits (Reference 23). Amendment No. 92 was approved on June 19, 2013, and implemented an alternative source term for the fuel-handling accident (FHA) (Reference 24). Section 3.4 discusses the proposed amendment's impact on the radiological consequences of affected design-basis accidents (DBAs).

2.2 System Description

The proposed amendment would change the maximum number of TPBARs allowed to be loaded in the WBN Unit 1 core to be 1,792. The exact number of TPBARs loaded is to be identified in the SE performed by Westinghouse for each core reload and noted in the Core Operating Limits Report (COLR) (Reference 1). Section 4.2.1, "Fuel Assemblies" of the TSs describes the number of fuel assemblies and the maximum number of TPBARs allowed to be loaded in the WBN Unit 1 core. The current cold-leg accumulator (CLA) and refueling water storage tank (RWST) boron concentration requirements in SR 3.5.1.4, "Accumulators," and 3.5.4.3, "Refueling Water Storage Tank (RST)," would not be changed by the proposed amendment. Instead, the proposed changes would remove information from SRs 3.5.1.4 and 3.5.4.3 to simplify the information contained in these SRs. These proposed changes are discussed in Section 3.6.

The March 31, 2015, submittal included an enclosure with updated information regarding the environmental impacts associated with tritium production (Reference 1) beyond the environmental assessment performed for Amendment No. 40. This information was updated and superseded by subsequent submittals dated June 5, 2015, September 25, 2015, and March 11, 2016 (References 4, 6, and 11, respectively). Section 3.4 addresses the staff's evaluation of post-accident radiological doses from the proposed amendment. Section 3.5 discusses the Occupational and Public Dose considerations for the proposed amendment.

2.3 Proposed Technical Specification Changes

The licensee is requesting three TS changes. The first TS proposed change for TS 4.2.1, "Fuel Assemblies," increases the maximum number of TPBARs allowed for loading into the WBN Unit 1 core from 704 to 1,792.

The other two TS proposed changes remove information from the SRs for boron concentration in the CLAs and RWST, SR 3.5.1.4 "Accumulators" and SR 3.5.4.3, "RWST," respectively, to delete the associated note and the table related to TPBARs.

The proposed amendment would change the TS SR 3.5.1.4, "Accumulators," to delete the associated note and the table related to TPBARs and revise the SR to read:

> Verify boron concentration in each accumulator is ≥ 3000 ppm and ≤ 3300 ppm.

This proposed amendment would also revise TS SR 3.5.4.3, "RWST," to delete the associated Note and the table related to TPBARs and revise the SR to read:

> Verify boron concentration in the RWST is ≥ 3100 ppm and ≤ 3300 ppm.

2.4 Regulatory Requirements and Guidance

The primary regulatory requirement being used to evaluate this license amendment request can be found in Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.46, "Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors." This regulation requires adequate core cooling following a LOCA such that specified acceptance criteria are satisfied. In particular, the core temperature must be maintained at an acceptably low value by appropriate removal of decay heat for the extended cooling period required by the long-lived radioactive nuclides in the core.

The post-LOCA long-term core cooling analysis for WBN Unit 1 requires that the core remain subcritical when all sources of liquid are injected and mixed in the containment sump. This includes the liquid from: (1) the RCS, (2) the CLAs, (3) the RWST, (4) the melted liquid from the ice condenser, and (5) any other possible sources of liquid. The resulting boron concentration must be sufficient to preclude criticality in the core, assuming cold conditions and the most reactive time in the cycle. The increase in the number of TPBARs loaded in the core will affect the criticality of the core because an increased U-235 loading in the core is necessary to support the increase in TPBARs, due to the strong neutron-absorbing properties of the TPBARs.

Section 50.61 of 10 CFR, "Fracture toughness requirements for protection against pressurized thermal shock events," contains requirements to prevent potential failure of the reactor vessel as a result of postulated pressurized thermal shock events. In particular, this rule discusses the use of a screening criterion evaluated at the projected fluence experienced by the reactor vessel during its service lifetime.

Section 50.36 of 10 CFR, "Technical specifications," includes requirements for the contents of the TS. This may include design features limiting the number of TPBARs that can be loaded into the core, as well as surveillance requirements (SRs) that ensure that the limiting conditions for operation (LCOs) will be met.

Section 50.36(c)(3) of 10 CFR states that SRs are requirements relating to test, calibration, or inspection to assure that the necessary quality of systems and components is maintained, that facility operation will be within safety limits, and that the LCOs will be met.

Section 50.34(b)(3) of 10 CFR is applicable as it pertains to describing "the kinds and quantities of radioactive materials expected to be produced in the operation and the means for controlling and limiting radioactive effluents and radiation exposures within the limits set forth in [10 CFR] part 20 ...."

Part 20 of 10 CFR is applicable as it pertains to ensuring that radiation doses are within the dose limits for occupational workers and members of the public, and are as low as is reasonably achievable (ALARA).

Part 50 of 10 CFR, Appendix I, is applicable as it pertains to ensuring that the routine radioactive effluent releases are within the design objectives to meet the ALARA criterion.

Section 50.120 of 10 CFR, "Training and qualification of nuclear power plant personnel," states that each holder of an operating license shall establish, implement, and maintain a training program that is derived from a systems approach to training and provides for the training and qualification of nuclear power plant personnel.

Section 100.11 of 10 CFR, "Determination of exclusion area, low population zone, and population center distance," requires, in part, that the licensee determine:

> (1) An exclusion area of such size that an individual located at any point on its boundary for two hours immediately following onset of the postulated fission product release would not receive a total radiation dose to the whole body in excess of 25 rem [roentgen equivalent man] or a total radiation dose in excess of 300 rem to the thyroid from iodine exposure.
>
> (2) A low population zone of such size that an individual located at any point on its outer boundary who is exposed to the radioactive cloud resulting from the postulated fission product release (during the entire period of its passage) would not receive a total radiation dose to the whole body in excess of 25 rem or a total radiation dose in excess of 300 rem to the thyroid from iodine exposure.

Section 50.67 of 10 CFR, "Accident source term," requires, in part, that:

> (i) An individual located at any point on the boundary of the exclusion area for any 2-hour period following the onset of the postulated fission product release, would not receive a radiation dose in excess of 0.25 Sv (25 rem) total effective dose equivalent (TEDE), (ii) An individual located at any point on the outer boundary of the low population zone, who is exposed to the radioactive cloud resulting from the postulated fission product release (during the entire period of its passage), would not receive a radiation dose in excess of 0.25 Sv (25 rem) total effective dose equivalent (TEDE), and (iii) Adequate radiation protection is provided to permit access to and occupancy of the control room under accident conditions without personnel receiving radiation exposures in excess of 0.05 Sv (5 rem) total effective dose equivalent (TEDE) for the duration of the accident.

Appendix A, "General Design Criteria [GDC] for Nuclear Power Plants," to 10 CFR Part 50 establishes the minimum requirements for the principal design criteria for water-cooled nuclear power plants. The principal design criteria establish the necessary design, fabrication, construction, testing, and performance requirements for structures, systems, and components (SSCs) important to safety. According to Section 3.1.1 of the WBN Unit 1, Updated Final Safety Analysis Report (UFSAR), the WBN plant was designed to meet the intent of the "Proposed General Design Criteria for Nuclear Power Plant Construction Permits" published in July 1967. The WBN construction permit was issued in January 1973. The WBN plant, in general, meets the intent of the NRC GDC published as Appendix A to 10 CFR Part 50 in July 1971, as discussed in UFSAR Section 3.1.2.

> GDC-10, "Reactor Design," requires the reactor core and associated reactor coolant, control, and protection systems to be designed with appropriate margin to assure that

specified acceptable fuel design limits are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences (AOOs).

GDC-15, "Reactor coolant system design," requires the RCS and associated auxiliary, control, and protection systems to be designed with sufficient margin to assure that the design conditions of the reactor coolant pressure boundary are not exceeded during any condition of normal operation, including AOOs

GDC-19, "Control room," states, in part:

> A control room shall be provided from which actions can be taken to operate the nuclear power unit safely under normal conditions and to maintain it in a safe condition under accident conditions, including loss-of-coolant accidents. Adequate radiation protection shall be provided to permit access and occupancy of the control room under accident conditions without personnel receiving radiation exposures in excess of 5 rem [0.05 Sv] whole body, or its equivalent to any part of the body, for the duration of the accident.

GDC-27, "Combined reactivity control system capability," requires that the reactivity control systems be designed to have a combined capability, in conjunction with poison addition by the emergency core cooling system (ECCS), of reliably controlling reactivity changes under postulated accidents conditions.

NUREG-0800, "Standard Review Plan [SRP] for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR [Light-Water Reactor] Edition."

Chapter 4, "Reactor," provides guidance for the review of fuel rod cladding materials, the fuel system, the design of the fuel assemblies and control systems, and the thermal and hydraulic design of the core. Section 4.2, "Fuel System Design," provides guidance for the review to provide assurance that:

- The fuel system is not damaged as a result of normal operation and AOOs,
- Fuel system damage is never so severe as to prevent control rod insertion when it is required,
- The number of fuel rod failures is not underestimated for postulated accidents, and
- Coolability is always maintained.

Chapter 11, "Radioactive Waste Management," provides guidance and acceptance criteria for determining the impact of the proposed change on plant effluent treatment systems and whether the ALARA design criteria of 10 CFR Part 50, Appendix I are met.

Chapter 12, "Radiation Protection," provides guidance and acceptance criteria for determining whether radiation protection design feature, and programs, are sufficient to ensure that requirements of 10 CFR Part 20 are met such that there is reasonable assurance that occupational doses, and doses to members of the public, will be maintained within the limits, and will be ALARA.

Chapter 13, "Conduct of Operations," Section 13.2.1, Revision 3, "Reactor Operator Requalification Program; Reactor Operator Training," provides guidance for reviewing the impact of the proposed change on the operator training program. In addition, Section 13.5.2.1, Revision 2, "Operating and Emergency Operating Procedures," provides guidance for reviewing the impact of the proposed change on operating and emergency operating procedures.

Chapter 15, Revision 3, "Transient and Accident Analysis," provides guidance for verifying that the proposed change is bounded by previous license amendments approved by the NRC with respect to the remaining analysis acceptance criteria for transient and accident analyses.

Chapter 18, Revision 2, "Human Factors Engineering," provides guidance for Human Factors Engineering Program reviews.

The following regulatory guidance is relevant:

RG 1.4, "Assumptions used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Pressurized Water Reactors," Revision 2.

RG 1.24, "Assumptions used for Evaluating the Potential Radiological Consequences of a Pressurized Water Reactor Radioactive Gas Storage Tank Failure," Revision 0.

RG 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1.

RG 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors," Revision 0.

RG 1.195, "Methods and Assumptions for Evaluating Radiological Consequences of Design Basis Accidents at Light-Water Nuclear Power Reactors," Revision 0.

RG 1.196, "Control Room Habitability at Light-Water Nuclear Power Reactors," Revision 1.

RG 8.32, "Criteria for Establishing a Tritium Bioassay Program," Revision 0.

American National Standards Institute (ANSI) N13.14, "Internal Dosimetry Programs for Tritium Exposure - Minimum Requirements."

NUREG-1764, "Guidance for the Review of Changes to Human Actions," Revision 1.

Generic Letter 82-33, "Supplement 1 to NUREG-0737 – Requirements for Emergency Response Capability."

NUREG-0700, "Human-System Interface Design Review Guidelines," Revision 2.

NUREG-0711, "Human Factors Engineering Program Review Model," Revision 3.

3. 0 Technical Evaluations

3.1 TPBAR-Related Core Design Changes

Increasing the number of TPBARs loaded in the core will impact several aspects of operation at WBN Unit 1. The lithium 6 (Li-6) in the TPBARs is a strong neutron absorber, so the U-235 loading in the core must be increased in order to meet cycle energy requirements. This increase in enrichment may require additional integral fuel burnable absorbers (IFBAs) to control power peaking and satisfy core design limits. Prior to each core load the number of TPBARs loaded and core design will be evaluated in the reload SE and documented in the COLR (Reference 1).

For WBN Unit 1, the representative core design used for this LAR compared to the previous Amendment No. 77 (Reference 18) is listed in Table 3.1.

Table 3.1 Representative Core Designs

Amendment	# fresh feed assemblies	# TPBARs	# IFBAs
Proposed amendment	92	1,792	14,912
Amendment No. 77	85	704	9,644

3.1.1 Core Physics

The significant increase in U-235 and burnable absorbers can be expected to affect the core physics characteristics of the reactor core. The NRC staff reviewed the representative core designs approved by Amendment No. 40 (WBN Unit 1 specific, with 96 feed assemblies and 2,304 TPBARs) and the DOE Topical Report (Reference 12) (non-plant-specific, with 140 feed assemblies and 3,344 TPBARs). The number of feed assemblies and TPBARs given in the proposed amendment are bounded by these two core designs, however, the proposed amendment has a significantly higher number of IFBAs (14,912 vs. less than 10,000 for the other two core designs). The absorption cross section for Boron-10 (B-10) and Li-6 exhibit a very similar 1/v dependence on neutron energy at the thermal energies where most fission occurs, so the overall impact on the core physics is very similar for the two neutron absorbers.

The licensee's RAI response by letter dated November 30, 2015 (Reference 7) provided an equilibrium WBN Unit 1 core loading pattern that identifies the location of the TPBARs and IFBA rods. The licensee provided a comparison of core design parameters, such as total number of feed assemblies, feed loading, number of TPBARs, total grams of tritium produced, initial Li-6 linear loading (g/in), active absorber height (in), average Li-6 fraction remaining, average grams of tritium produced per TPBAR, and peak grams of tritium produced per TPBAR between the DOE Tritium Production Core (TPC) Topical Report (Reference 12) values, WBN Unit 1 equilibrium cycle, and WBN Unit 1 equilibrium core with 1,792 TPBARs. Comparing the values in the provided table of Reference 7, the NRC staff determined that the proposed 1,792 TPBAR representative core is within the design parameters as expressed in the aforementioned NRC-approved topical report and SE (References 12 and 13).

Due to the large residual reactivity penalty of TPBARs relative to conventional burnable absorbers because of large Li-6 loading and relatively low thermal neutron absorption, a TPC must load a larger number of feed assemblies at higher U-235 enrichment. The staff has determined that the core design parameters of the proposed amendment are bounded by the analysis in NUREG-1672 and the plant specific implementation values approved by Amendment No. 40. A discussion of specific core design parameters evaluated by the NRC staff is discussed below.

3.1.1.1 Impact on Neutronic Factors and Reactivity Coefficients

The NRC staff has evaluated the licensee's assessment of the following core parameters, such as: nuclear enthalpy rise factor, total peaking factor, axial power distributions, moderator coefficient of reactivity, Doppler temperature coefficient, control rod worth, and shutdown margin. The licensee states that the proposed 1,792 TPBAR core is within the design parameters described in the NRC-approved TPC Topical Report (Reference 13) and Amendment No. 40 (Reference 14). The NRC staff verified that the core reactivity parameters for the proposed 1,792 TPBAR representative core design are consistent with the staff's assessment in NUREG 1672 and Amendment No. 40 (References 13 and 14).

Any cycle-to-cycle variations in the calculated values and their comparison to the Safety Analysis of Record reload specific limits are required to be addressed as part of the Westinghouse Reload Safety Analysis Checklist per the NRC-approved methods (Reference 22). The staff finds that the proposed changes to increase the maximum number of TPBARs to 1,792 will not have a substantial effect on the previously approved methodologies for determining the neutronic factors and reactivity coefficients. Therefore, the staff finds the proposed change to be acceptable and that the requirements of GDC-10 and GDC-27 will continue to be met.

3.1.1.2 Impact on Fuel Design and Performance Parameters

The RAI response dated November 30, 2015 (Reference 7) provided information on the impact of the increase in the number of TPBARs in WBN Unit 1 on the following fuel design parameters:

(a) Rod internal pressure (RIP) as a function of fission gas release (FGR)
(b) Cladding stress
(c) Cladding strain
(d) Cladding oxidation and hydriding
(e) Fuel temperature
(f) Cladding fatigue
(g) Fuel rod axial growth
(h) Clad flattening
(i) Clad creep

In Reference 7, the licensee states that the fuel rod design criteria are evaluated on a cycle-specific basis to ensure that all limits are met and that the safety analyses are valid. Reference 7 states that the change in the number of TPBARs affects power histories and transient powers used in design analyses. [[

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In Reference 7, the licensee describes the assessment of margins in RIP, transient strain, and cladding corrosion due to the increase in the TPBARs loading. [[

]] As a result, the corresponding departure from nucleate boiling (DNB) propagation and other cladding corrosion criteria (hydrogen pickup limit) change by amounts comparable to the RIP. The licensee states that the available margins are large and can offset any of the margin reductions due to the increase in the number of TPBARs. The NRC staff finds the licensee's assessment to be reasonable given that the increase in TPBARs maintains the margin for the above fuel performance parameters. Therefore, the staff finds the proposed increase in TPBARs to have a negligible impact on the conclusions documented in NUREG 1672 and those plant-specific issues previously approved in Amendment No. 40 with respect to the fuel design and fuel performance requirements of the approved Westinghouse reload analysis (Reference 22).

3.1.1.3 Impact of TPBAR Increase on Safety Parameters due to Lack of Thermal Conductivity Degradation (TCD)

The RAI response dated November 30, 2015 (Reference 7) provided information on the impact of the proposed increase in TPBAR loading on the safety parameters such as fuel rod stored energy, fuel rod centerline temperature, and Doppler power coefficient due to the lack of explicit treatment of TCD in safety analysis.

In References 20 and 21, Westinghouse reviewed and assessed the NRC letter dated December 16, 2011, regarding evaluation of nuclear fuel TCD for LWRs using Westinghouse codes and methods. In Reference 7, the licensee states that the increase in TPBARs has no effect on the assessment conducted in Reference 20. [[

]] For cycle-specific design criteria [[

]]. Therefore, the NRC staff agrees that sufficient margin is available to offset the effect of TCD with the proposed increase in TPBARs. The NRC staff finds that there is reasonable assurance that the requirements of GDC-10 and GDC-27 will continue to be met with the proposed increase in the maximum allowed number of TPBARs loaded in the core.

3.1.2 Vessel Fluence

Section 50.61 of 10 CFR contains a requirement for licensees to perform a screening assessment of their reactor vessel based on a projected end-of-life fluence. The representative core design contains 92 feed assemblies. Since WBN Unit 1 has 193 fuel assemblies, this implies that a representative core design will have 92 fresh fuel assemblies, 92 once-burned fuel assemblies, and 9 twice-burned fuel assemblies. If a problem arises that requires early discharge of a fuel assembly, such as a leaking fuel rod, then the number of fresh or once-burned fuel assemblies may be increased in a subsequent core design to compensate for the loss of energy from the early discharge. As a result, the expectation will be that a significant number of once-burned fuel assemblies will be loaded on the core periphery. The high enrichment, lower burnup fuel will tend to increase core leakage, which may affect the projected end-of-life fluence.

Amendment No. 40 approved a representative WBN Unit 1 core design with significant numbers of low burnup fuel on the periphery. As discussed in Section 2.4.1 of the accompanying SE (Reference 14), the NRC staff determined that the representative tritium production core design was bounded by the WBN Unit 1 design basis vessel fluence evaluation. However, this is due in part to the licensee inserting TPBARs in key locations to suppress power in key peripheral fuel assembly locations, thus reducing the fluence to a value more comparable to low leakage core designs. The proposed amendment is requesting approval for 512 fewer TPBARs, with a reduction in feed of only 4 assemblies. Therefore, the staff requested additional information (ADAMS Accession No. ML15226A466) to confirm that the licensee will continue implementing appropriate core design strategies to maintain the projected vessel fluence within the design basis assumptions.

The licensee responded (Reference 5) by indicating that the radial power distribution for the core design used as a reference for this LAR was compared to the radial power distribution used to assess the vessel lifetime (DOE topical report, Reference 12). The fuel assembly powers in the core locations important to the fluence for the limiting vessel location were found to be lower for the current reference core design (with 1,792 TPBARs). Therefore, no additional absorbers were necessary to suppress the fluence. However, there are other locations near the periphery where the assembly powers are higher than the power distribution assumed in the licensee's analysis of record for vessel fluence.

In the RAI response dated September 14, 2015 (Reference 5), the licensee stated that it would evaluate the vessel fluence accumulation for future cycles using the new power distribution to verify that the change in power distribution does not lead to a new limiting vessel location for fluence. If necessary, the licensee stated that it would impose power distribution constraints on future core designs. The staff finds this to be an acceptable approach to ensure that the fluence analysis of record will remain bounding, thus ensuring that the 10 CFR 50.61 requirements continue to be met.

3.1.3 Post-LOCA Criticality Analysis

Increased TPBAR loading can affect the post-LOCA cooling requirements (10 CFR 50.46) and therefore impact the accident analyses. Per the requirements in 10 CFR 50.46, the licensee must demonstrate that adequate cooling of the core can be maintained for an extended period of time after a LOCA occurs. In the WBN Unit 1 plant-specific analyses, one of the assumptions is that the core is maintained in a subcritical condition throughout the period of cooling. Therefore, the licensee must confirm that the core will remain subcritical under conservative long-term cooling conditions.

The tritium-producing cores are designed to preserve similar boron concentrations during normal operating conditions. However, the presence of a large amount of strong neutron absorber materials tends to reduce the reactivity worth of any further addition of B-10 to the core. This is due to the fact that the existing thermal absorption of neutrons shifts the neutron spectrum towards higher energies (i.e., spectral hardening). When the additional B-10 is added to the core, there are not as many neutrons available at thermal energies for absorption. Therefore, the B-10 absorbs more neutrons at higher energies, where its neutron absorption is not as efficient. Furthermore, the possibility exists for loss of Li-6 material from the TPBARs due to rod failure. All other things being equal, the boron concentration will need to be higher for post-LOCA sub-criticality when the number of TPBARs present in the core is increased.

3.1.3.1 Changes in Post-LOCA Criticality Analysis

The licensee performed a post-LOCA sub-criticality assessment, using a methodology very similar to that evaluated in Amendment No. 77 (Reference 18), using the same codes and general methodology. In the proposed amendment, the licensee changed two key assumptions that allowed the licensee to decrease the predicted reactivity in the post-LOCA criticality analyses: (1) the TPBAR failure and lithium leach rate, and (2) elimination of post-LOCA dilution paths.

TPBAR Failure and Leach Rate

In Amendment No. 77, the NRC approved the very conservative assumption that if the TPBARs failed, 50 percent of the lithium would leach out of the core by the time of the Hot Leg Switchover (HLSO, at 3 hours). In the current LAR, the licensee references lithium leach tests performed by PNNL to justify usage of a time dependent leaching rate, where the amount of lithium assumed to have leached out of the core is 3 percent at the time of HLSO. Therefore, the post-LOCA HLSO sub-criticality analyses are performed with a total lithium loss of 3 percent, with the remaining lithium available to hold down reactivity. The post-LOCA long term cooling analyses assume the same maximum leach-out amount of 50 percent as prior LARs.

In order to evaluate the licensee's rationale for using the revised assumption for the leaching rate, the NRC staff requested additional information (ADAMS Accession No. ML15226A466). The staff's RAI was needed to determine if the PNNL experiments could be considered to be satisfactorily representative of the post-LOCA environment, and if the projected TPBAR temperatures during post-LOCA conditions are bounded by the PNNL experiments. The licensee responded to the RAI by letter dated September 14, 2015 (Reference 5) that generally discussed the technical justification for the applicability of the test results to the post-LOCA environment. The NRC staff determined that a further review of the relevant test documentation was required, so an audit was performed at PNNL (ADAMS Accession No. ML15345A424) and a docketed response was submitted by the licensee on December 29, 2015 (Reference 9).

The staff's review goals were to confirm that: (1) the testing results are representative of post-LOCA conditions, (2) the testing results support the lithium loss assumed in the licensee analyses, and (3) the modeling used in the licensee analyses is an appropriate application of the lithium loss assumptions. The lithium leaching test data was the primary area of focus, since this data directly supported the revised leaching rate assumption. However, the NRC staff also reviewed information related to TPBAR bursting tests and the associated analysis assumption of a 12-inch gap for the lithium in the TPBARs to confirm that the combined analysis assumptions regarding lithium loss remain conservative.

The licensee provided a summary of the leaching test results and their applicability in Reference 9. The post-LOCA environment was described as being bounded by the test conditions due to the lack of significant coolant interaction with the lithium material not ejected through bursting of the TPBARs, and the maximum calculated temperature for the TPBARs during post-LOCA conditions. In summary, the test conditions were run using conditions that would be expected to maximize the lithium leaching relative to post-LOCA conditions by use of a higher temperature and slightly greater exposure to the environment (smoothly cut edges versus the deformations resulting from a burst TPBAR). The burst test results (excerpted in Reference 9 for the Mark 9.2 TPBAR design, which is the currently utilized TPBAR design) were reviewed to ensure that the test conditions at bursting were reasonably representative of expected conditions in the WBN Unit 1 core. The NRC staff finds that the exact initial conditions are relatively unimportant, since the test occurs over a sufficiently short time scale to make the structural failure characteristics of the TPBARs primarily dependent on the conditions at the time of failure. The staff found that the axial power shape and the approximate peak post-LOCA cladding temperatures were reasonably captured at the time of failure, and that the failure pressure was varied to meet pre-determined targets by adjusting the initial TPBAR fill pressure. The leaching tests show a maximum leaching rate of less than 3 percent per day. HLSO is expected to occur at about 3 hours, so use of a 3 percent lithium loss due to leaching is bounding. The burst test results are used to support the assumption of a maximum 12-inch gap. A statistical analysis performed as part of the PNNL test documentation (excerpted in Reference 9) shows that the burst test results demonstrate that a 12-inch gap bounds the lithium pellet loss required by the analysis methodology of record. No further bursting of TPBARs in an alternate location would be expected after the initial burst, due to the virtually complete release of pressure immediately after bursting occurs for the test TPBARs. The staff finds the licensee's application of the leaching test results in the analysis to be reasonable and conservative.

In the post-LOCA sub-criticality assessments, the leaching rate assumptions are applied in a straightforward, core-wide fashion. The staff finds the leaching rate to be conservative because the leach test results were based on a short, open ended section with two TPBAR pellets. The 3 percent loss value based on the test results was conservatively applied to the entire rod length of all TPBARs, even though most of the pellets would not have a direct interface with the ambient fluid. For the 12-inch gap modeled as a result of TPBAR bursting assumptions, the licensee documentation did not explicitly describe what axial node(s) the 12-inch gap was modeled at. The staff requested information about how a change in the location of the modeled gap may affect the calculated reactivity. The licensee indicated (Reference 9) that due to a very pronounced core average power shape, the most reactive node(s) for individual assemblies was identical to the limiting nodes selected for the 12-inch gap based on the core average power distribution. The licensee performed a further sensitivity study to disposition the impact of modeling the 12-inch gap in TPBAR material at different axial locations.

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The staff concludes that the licensee's approach as described in Reference 9 is a reasonable approach to confirm the validity of the TPBAR burst assumption reviewed as part of this methodology.

Based on the above discussion of the results from the lithium leaching tests and TPBAR burst tests and how they are used to develop conservative assumptions for the post-LOCA behavior of the TPBARs, the staff finds the potential for lithium loss to have been addressed in a conservative manner for the post-LOCA subcriticality assessments for a representative core design. The assumptions associated with the axial location of the modeled 12-inch gap in the TPBAR material will, however, need to be verified for each future core design to confirm that the lithium leach rate and TPBAR burst assumptions reviewed in this amendment request, as supplemented, remain valid. As stated in Reference 1, the number of TPBARs to be irradiated in any given operating cycle will be evaluated in the reload safety evaluation and documented in the COLR. In Reference 9, the licensee further described an acceptable approach to assess the validity of key post-LOCA criticality assessment assumptions for the axial location of the TPBAR bursts. The staff finds that the methods and assumptions discussed above will provide adequate assurance that the potential reactivity impacts due to loss of lithium absorber material due to leaching or TPBAR bursting are bounded, ensuring that the post-LOCA cooling requirements in 10 CFR 50.46 continue to be met. Therefore the staff finds the proposed amendment, as supplemented, to be acceptable.

Potential Post-LOCA Dilution Paths

The post-LOCA sub-criticality assessment is performed for three potentially limiting times during the evolution of the LOCA event: (1) the reflood stage, (2) HLSO, and (3) long-term cooling. The latter two conditions involve liquid injection into the reactor vessel from the containment sump, so an assumed value for the boron concentration at the sump must be determined. Prior analyses used sump boron concentration curves that included a 40-gallon per minute (gpm) unborated dilution source that would enter the containment and be isolated within 16 hours after the break. The basis for this possibility is discussed in Section 6.2 of the WBN Unit 1 UFSAR. Four lines were identified as not being adequately protected from a high-energy line break and utilize a check valve as an inboard containment isolation valve, and required operator action to manually isolate the line if it should break (page 6.2.4-5). Of these four lines, one would only supply air to the containment and thus is not a concern for dilution accidents. The remaining three lines represented potential short-term dilution sources. In addition, the cooling coils in the upper compartment coolers are not seismically qualified and the ERCW supply penetrations use check valves as inboard containment isolation valves, which would also require operator action in the event of cooling coil rupture.

In order to remove this potential dilution source, the licensee committed to: (1) replacing the upper compartment cooler cooling coils with fully qualified cooling coils, and (2) replacing existing check valves with simple relief valves on the lower compartment supply lines for the ERCW system and CCS, which would provide automatic containment isolation. However, the WBN Unit 1 UFSAR also identifies the possibility of backflow through the CCS return line via check valve 1-CK-70-698. In the RAI dated August 14, 2015, the NRC staff inquired about the CCS return line and whether the check valve on this line would be replaced as well, and if not, why this line is not considered to be a potential dilution source. The licensee responded

(Reference 5) by updating their regulatory commitments to include the CCS return line check valve in the list of CCS check valves to be replaced.

In the March 31, 2016, supplement, the licensee confirmed that all the check valves were replaced and updated the list of Regulatory Commitments in Enclosure 6 to delete Commitment 1 (Reference 11). The March 31, 2016, supplement Enclosure 5 proposed a license condition for the replacement of the Unit 1 upper compartment cooler cooling coils with safety-related cooling coils to eliminate a potential source of containment sump dilution during design-basis events prior to increasing the number of TPBARs loaded in the core above 704. The staff finds the license condition and the replacement of the check valves listed in Reference 11 as appropriate actions to remove all potential dilution sources in the containment that could result from broken pipes in the containment due to impingement of other broken pipes or fluid jets. As a result, the staff finds that reasonable assurance exists that there will be no potential dilution sources during post-LOCA conditions, therefore, the licensee's elimination of dilution sources from the post-LOCA sub-criticality assessment is acceptable and the requirements of 10 CFR 50.46 will continue to be met.

3.2 Boron Concentration

The staff reviewed the remaining analysis methodology and assumptions to verify that they remained applicable for the proposed amendment. In general, the methodology and assumptions are consistent with prior precedents, and remain applicable for the representative tritium-producing core design. However, one of the assumptions described by the licensee in Reference 1 did not appear to be conservative for the long term assessments. In Reference 1, the licensee explains that when determining the sump boron concentration, the boron concentrations and liquid masses are selected to minimize the final boron concentration. In particular, the RWST, ice mass, and accumulator fluid masses are assumed to be at a minimum value and the RCS fluid mass is assumed to be at a maximum value (since the RCS liquid has a low boron concentration and, thus, serves as a dilution source). The RWST and accumulator fluid is at a very high boron concentration, but the ice mass has a boron concentration of only 1,800 ppm. Review of the analysis results shows that the sump boron concentration is lower than 1,800 ppm for the HLSO analysis, thus use of a minimum ice mass is conservative. However, this is not true for the long-term cooling subcriticality assessments. The NRC staff requested additional information to address this apparent non-conservatism, and the licensee responded by letter dated September 14, 2015, indicating that the wording in the March 31, 2015, submittal was incorrect. The discussion provided by the licensee (Reference 5) clarifies that all of the fluid masses are biased in the appropriate direction for conservatism in the sub-criticality assessment; in essence, they are always skewed towards reducing the combined boron concentration due to the multiple liquid sources.

Based on the licensee's explanation in Reference 5 of how the fluid masses were biased for conservatism, the staff finds the licensee's treatment of the amounts of liquid combined to produce the final boron concentration used for the sub-criticality assessment to be acceptable.

3.3 Human Factors Review of Proposed Change

The NRC's Probabilistic Risk Assessment Operations and Human Factors Branch (APHB) reviewed the elimination of operator actions to isolate unborated dilution sources in this section with respect to human factors implications. As discussed in this SE at Section 3.1.3.1, subsection "Potential Post-LOCA Dilution Paths," the licensee replaced check valves with simple relief valves on the ERCW (supply) and CCS (supply and return) lines to provide automatic containment isolation. In Reference 11, the licensee deleted a commitment to replace existing check valves with simple relief valves on the lower compartment supply lines for the ERCW and CCS systems because the valves were replaced during the last WBN Unit 1 refueling outage. The changes to the plant eliminate the need for manual isolation of the six-inch ERCW supply to the lower containment cooler Group D from the main supply Header 1B, and manual isolation of the six-inch CCS supply and return lines for the reactor coolant pump oil cooler penetrating containment, during an accident. Therefore, the review in this section is limited to the elimination of operator actions to isolate unborated dilution sources as described in Reference 1 as supplemented by References 3 and 11.

3.3.1 Associated Risk

In accordance with the generic risk categories established in Appendix A to NUREG-1764, "Guidance for the Review of Changes to Human Actions," the elimination of operator actions to isolate unborated dilution sources reviewed herein is not considered "risk-important" due to the fact that it reduces the operators' workload during an accident, thereby reducing the overall risk. Because of its low-risk importance, the APHB staff performed a "Level Three" review (i.e., the least stringent of the graded reviews possible under the guidance of NUREG-1764). The APHB staff's assessment of risk is only for purposes of scoping the APHB review and may conflict with the licensee's assessment of risk importance or that of other branches, and should not be considered as an accurate assessment of risk when compared to other methods, especially, those using plant-specific data and NRC-accepted methods of Probabilistic Risk Analysis and Human Reliability Analysis.

3.3.2 Description of Operator Actions Added/Changed/Deleted

As a result of its review of operator actions, the licensee has identified that a reduction in human error probability can be accomplished by replacing the containment isolation thermal relief check valves on the supply and return lines for the CCS and the supply lines for the ERCW System with simple relief valves (i.e., passive devices). This will reduce both the time required and the operator workload involved in isolating the CCS and ERCW systems as potential sources of unwanted boron dilution during execution of Emergency Operating Instruction 1-E-0, "Reactor Trip of Safety Injection." In Reference 3, the licensee identified no other operator actions that are required, or are affected by the proposed LAR as supplemented.

The following operator actions were implemented as part of License Amendment No. 51 that was approved by NRC staff on March 29, 2004 (Reference 16):

- manual isolation of the six-inch ERCW System supply to the lower containment cooler Group D from the main supply Header 1B by closing the safety-related valve 1-ISV-67-523B within 16 hours after the postulated accident, and
- manual isolation of the six-inch CCS supply and return lines for the reactor coolant pump oil cooler penetrating containment by closing valves 1-ISV-70-516 (supply) and 1-ISV-70-700 (return), as applicable, within 16 hours of the accident, concurrent with the single failure of the outboard containment isolation valve to close.

In Reference 11, the licensee confirmed replacement of the subject thermal relief check valves on the lower compartment supply and return lines to the containment for CCS and the supply lines for the ERCW System with simple relief valves (i.e., passive devices). Specifically, the check valves in the CCS (1-CKV-070-0687, -0698, -0790) and the ERCW System (1-CKV-067-1054A, -1054B, -1054C, -1054D) were replaced with new pressure relief valves (1-RFV-070-

0687, -0698, -0790, 1-RFV-067-1060A, -1060B, -1060C, and-1060D, respectively). The replacement of these valves represents a return to the pre-Amendment No. 51 design basis. Therefore, the staff finds the elimination of the manual operator actions described above to isolate containment to be acceptable.

3.3.3 Design Control

WBN uses TVA procedure NPG-SPP-09.3, "Plant Modifications and Engineering Change Control," to manage the content, impact review, and implementation of design changes. From the human factors perspective, this process provides assurance that the affected Disciplines and Departments review the change as it is developed for impact to items under their control, such as procedures, training, control room interfaces, and the simulator. The staff finds this process consistent with the criteria of NUREG-0711, "Human Factors Engineering Program Review Model," Revision 3.

3.3.4 Operating Experience Review

The licensee has had an extensive history of successful tritium production, beginning with the initial NRC approval letter to TVA dated September 15, 1997, "Issuance of Amendment on Tritium Producing Burnable Absorber Lead Test Assemblies (TAC No. M98615)" (ADAMS Accession No. ML020780128). The licensee documented this history in its March 15, 2015, submittal (Reference 1), showing a gradual increase in the number of TPBARs added in each operating cycle. In order to confirm this positive operating experience, the staff searched the ADAMS database for human errors associated with tritium production, including LARs, SEs, and Licensee Event Reports over the last 5 years, and found only one Institute of Nuclear Power Operations report on tritium releases that was not directly applicable to the tritium production process at WBN. The staff agrees with the licensee's assessment and finds the licensee's use of past operating experience acceptable.

3.3.5 Human-System Interface Design

The licensee stated in Reference 3, that Human-System Interface (HSI) design of the control room and the simulator, including the design of the Safety Parameter Display System, will not be affected by the proposed LAR. Based on the fact that no changes are needed to the current, approved HSI design, the staff finds the WBN proposal acceptable.

3.3.6 Procedure Design

In Reference 3, the licensee stated that TVA anticipates that changes to Emergency Operating Instruction 1-E-0, "Reactor Trip of Safety Injection," Revision 5, to remove the above described operator manual actions, will be necessary. No other procedure changes have been identified. The staff finds that the licensee has correctly identified procedures impacted and has stated that revisions will be made. On this basis, the staff finds the procedure design acceptable.

3.3.7 Training Program Design

The licensee stated in Reference 3 that operator training on the deletion of the operator manual actions will be required. Based on its incorporation of the deleted actions into the training program, the staff finds the proposed changes will continue to satisfy the requirements of 10 CFR 50.120, "Training and qualification of nuclear power plant personnel."

3.3.9 Human Factors Verification and Validation

No verification and validation of operator tasks or procedures is necessary, because there are no operator manual actions being changed or added; only eliminated.

3.3.10 Human Factors Technical Conclusion
Based on the statements provided by TVA (i.e., that appropriate administrative controls are being applied to revise procedures and training, and that the Human-System Interface design is not affected by the proposed change), the staff concludes that the proposed amendment is acceptable and that the requirements of GDC-19 and 10 CFR 50.120 will continue to be met.

3.4 Post-Accident Radiological Dose

In Amendment No. 40 (Reference 14) the licensee assessed the following station accident analyses affected by the production of 2,304 TPBARs:

- Loss of offsite power (LOOP)
- Waste gas decay tank (WGDT) failure
- Loss of coolant accident (LOCA)
- Main steam line break (MSLB)
- Steam generator tube rupture (SGTR)
- Fuel handling accident (FHA)
- Failure of small lines carrying primary coolant outside containment
- Rod ejection accident

The analysis in Amendment No. 40 included:

- Revised initial source terms that took into account the tritium production core parameters.
- Dose conversion factors from the Environmental Protection Agency's Federal Guidance Reports 11 and 12.
- For accidents other than the FHA and LOCA, all of the tritium gas in two failed TPBARs (24,106.9 curies (Ci)) was released into the reactor coolant.

In addition in Amendment No. 40, TVA reported values for the total effective dose equivalent (TEDE) for informational purposes for each accident and the NRC staff determined that the TEDE supplements, but does not supplant, the whole-body and thyroid dose results in the WBN Unit 1 licensing basis.

3.4.1 Applicable Accident Analyses

The NRC staff evaluated the impact of increasing the maximum number of TPBARs that can be irradiated per cycle from 704 to 1,792 as it relates to the radiological consequences of affected DBAs that use the RCS inventory as the source term or predict fuel damage. As stated in RG 1.195, the source term assumed in radiological analyses should be based on the activity associated with the projected fuel damage or the maximum RCS TS values, whichever maximizes the radiological consequences. The limits on RCS specific activity ensure that the offsite doses are appropriately limited for accidents that are based on releases from the RCS with no significant amount of fuel damage.

To appropriately account for the radiological consequences of the increased tritium in the TPC, TVA included calculated TEDE[1] and Federal Guidance Report Number 11[2] effective dose conversion values in the accident analysis for informational purposes. TPBARs are designed to withstand the rigors associated with the American Nuclear Society Category I through IV events; therefore, no TPBAR failures are predicted by TVA to occur during the DBAs except for the LOCAs and the FHAs.

During the NRC staff's review of the impact of increasing the maximum number of TPBARs that can be irradiated per cycle, on all DBAs currently analyzed in the WBN UFSAR, the NRC staff determined that more information was needed to complete the review. In the June 15, 2015, supplement (Reference 4) the licensee stated that with one exception, the MSLB and SGTR inputs and assumptions are the same as those used to support License Amendment No. 91 (Reference 23) and that the one exception was the control room isolation delay time, which was increased from 40 seconds to 74 seconds to correct an error in how the delay time was determined. The NRC staff requested that the licensee provide additional detail on the error in control room delay time determination, and explain if this error applied to any other DBAs. The licensee responded in Reference 6 with the following:

> The control room radiation monitor loops utilize the RP-30AM analog ratemeter. A time constant of 7.17E-3 minutes was previously used to determine the ratemeter response time, which would be appropriate for a count rate between 1E4 to 1E5 counts per minute (cpm). However, the setpoint for these monitors is 400 cpm; thus a time constant of 4.34E-1 minutes should have been used. This resulted in an increase in the ratemeter response time from 0.86 seconds to 52.08 seconds. Combined with the response times determined for the remainder of the loop, the total loop response time increased from 6.6 seconds to 57.8 seconds. The analyses rounded this to 60 seconds.

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1 10 CFR Appendix B to Part 20--Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage

2 EPA-520/1-86-020, Federal Guidance Report No. 11 Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion. Washington, D.C.

This error is applicable to the following analyses referenced in ARCB RAI 3, which were reanalyzed with the higher isolation time:

- Main steam line break (MSLB)
- Steam generator tube rupture (SGTR)
- Loss of offsite power (LOOP)
- Waste gas decay tank (WGDT) failure
- Fuel handling accident (FHA)

In addition, the licensee stated that the error is not applicable to the LOCA, failure of small lines carrying primary coolant outside containment, or the rod ejection accident because the control room isolation is initiated directly on a safety injection signal that is initiated by the engineered safety feature actuation systems (ESFAS) in response to a LOCA as opposed to the control room radiation monitors. The NRC staff reviewed the licensee's response and agrees that the new control room isolation delay time applies to the radiological consequence analysis for the MSLB, SGTR, LOOP, WGDT, and FHA DBAs and does not apply to the LOCA or rod ejection DBAs.

3.4.2 Loss-of-Coolant Accident (LOCA)

In Reference 1, TVA stated that WBN License Amendment No. 40 and the current licensing basis consider that all of the tritium content of 2,304 TPBARs is released to the containment atmosphere after a LOCA. This is based on a design inventory of 1.2 grams of tritium per TPBAR and results in 2.68×10^7 Ci of tritium. The design inventory of tritium remains the same. Therefore, the current licensing basis LOCA radiological dose consequences analysis is bounding for the 1,792 TPBAR core. The NRC staff has reviewed License Amendment No. 40 and the WBN Unit 1 current licensing basis against this LAR and is in agreement with TVA's conclusion that the current licensing basis of 2,304 TPBARs is bounding for the LOCA because the amount of tritium produced per TPBAR remains the same and the number of TPBARs exceeds that which is requested in this license amendment request. Therefore, the amount of tritium produced from 1,792 TPBAR loading is bounded by the current licensing basis of 2,304 TPBARs.

3.4.3 Fuel Handling Accident (FHA)

In the application TVA stated that the source term used for the FHA is the same as the one used for the License Amendment No. 40 evaluation. License Amendment No. 40 and the WBN Unit 1 current licensing basis consider that all of the tritium content of 24 TPBARs is released into the surrounding water. This is the maximum number of TPBARs that would be in one fuel assembly. Since the issuance of License Amendment No. 40, TVA has modified the licensing basis for the FHA. License Amendment No. 92 was approved on June 19, 2013, and implemented an alternative source term for the FHA (Reference 24). Included in License Amendment No. 92 was a change to the amount of tritium that was released to the environment. License Amendment No. 40 assumed a 100 percent release and License Amendment No. 92 assumed a 25 percent release. However, in License Amendment No. 92 the maximum number of TPBARs in one assembly is 24, and this number remains the same in the proposed amendment. In addition, the amount of tritium produced in a TPBAR remains the same. Because the amount of tritium produced per TPBAR and the maximum number of TPBARs in one fuel assembly remains the same, the source term released to the surrounding water is not affected. Therefore, the NRC staff has determined that the TPBAR assumptions in the current licensing basis remain bounding for the FHA.

The licensee proposed a new control room isolation delay time, which is increased from 40 seconds to 74 seconds to correct an error in how the delay time was determined. The corrected control room isolation delay time of 74 seconds is used in both the FHA in the spent fuel pool/auxiliary building and FHA in containment analyses. The NRC staff reviewed the FHA with regard to the new control room isolation delay time.

The accident analyses for an FHA, including the assumed parameters, are presented in Section 15.5.6 of the WBN Unit 1, UFSAR. With the exception of the new control room isolation delay time, the licensee has not proposed any changes to the FHA analysis previously performed as described in the UFSAR.

The licensee evaluated the radiological consequences resulting from the postulated FHA and concluded that the radiological consequences at the exclusion area boundary (EAB), the low-population zone (LPZ), and the control room comply with the reference values provided in 10 CFR 50.67 and the accident specific dose guidelines specified in RG 1.183. The NRC staff's review found that the licensee used analyses, assumptions, and inputs consistent with applicable regulatory guidance identified in RG 1.183. The other assumptions previously found acceptable to the NRC staff are presented in the WBN Unit 1, UFSAR. The licensee's calculated dose results are given in Table 3.4.1 below. The NRC staff performed independent confirmatory dose evaluations, as necessary, to ensure a thorough understanding of the licensee's methods. The NRC staff finds, with reasonable assurance, that the licensee's estimates of the dose consequences of a design basis FHA will comply with the requirements of 10 CFR 50.67 and the accident specific dose guidelines specified in RG 1.183, and are, therefore, acceptable.

Table 3.4.1
Radiological Consequences for FHA

	Control Room	Exclusion Area Boundary (EAB)	Low Population Zone (LPZ)
Auxiliary Building (TEDE rem)	2.39E+00	2.83E+00	7.92E-01
Containment (TEDE rem)	2.33E+00	2.83E+00	7.92E-01

3.4.4 Main Steam Line Break (MSLB) and Steam Generator Tube Rupture (SGTR)

In the proposed amendment TVA stated that the source term for the MSLB and the SGTR has been updated to reflect a new permeation rate of 10 Ci per TPBAR per year. The current licensing basis assumes a tritium concentration based on a permeation rate of 1 Ci per TPBAR per year, 2,304 total TPBARs, and two failed TPBARs. This results in a concentration of 98.4 micro curies per gram (µCi/gm). The new updated RCS tritium activity to support the requested change is based on 2,500 TPBARs and the updated permeation rate of 10 Ci per TPBAR per year and two failed TPBARs, which results in a new concentration of 124.9 µCi/gm. In addition, the licensee stated that with one exception, the MSLB and SGTR inputs and assumptions are the same as those used to support License Amendment No. 91 regarding the change to the dose equivalent I-131 spike limit (Reference 23). The one exception is the control room isolation delay time, which is increased from 40 seconds to 74 seconds to correct an error in how the delay time was determined. The corrected control room isolation delay time of 74 seconds is used in both the MSLB and SGTR analyses.

The licensee's current licensing basis calculations demonstrate that no fuel damage is postulated for either the MSLB accident or the SGTR accident. Therefore, the activity released is based on the maximum coolant activity allowed by TSs. In performing the dose consequence analyses for a coolant release at maximum TS values, two radioiodine spiking cases are considered. The first case is referred to as a pre-accident iodine spike and assumes that a reactor transient has occurred prior to the postulated accident that has raised the primary coolant iodine concentration to the maximum value permitted by the TSs for a spiking condition. The second case assumes that the primary system transient associated with the accident causes an iodine spike in the primary system. This case is referred to as an accident-induced spike or a concurrent iodine spike. Initially, the plant is assumed to be operating with the RCS iodine activity at the TS limit for normal operation. The increase in primary coolant iodine concentration for the concurrent iodine spike case is estimated using a spiking model that assumes that as a result of the accident, iodine is released from the fuel rods to the primary coolant at a rate (500 times for MSLB and SGTR) that is much greater than the iodine equilibrium release rate corresponding to the iodine concentration at the TS limit for normal operation.

The accident analyses for a MSLB and a SGTR, including the assumed parameters, are presented in Sections 15.5.4 and 15.5.5 of the WBN Unit 1, UFSAR, respectively. Excluding the one exception stated above, the licensee has not proposed any changes to the operator actions and the thermal and hydraulic analysis previously performed to determine plant response for a postulated MSLB and a postulated SGTR accident as described in the UFSAR.

The licensee evaluated the radiological consequences resulting from the postulated MSLB and SGTR accidents and concluded that the radiological consequences at the EAB, the LPZ, and the control room comply with the reference values provided in 10 CFR 100.11 and the accident specific dose guidelines specified in RG 1.195. The NRC staff's review found that the licensee used analyses, assumptions, and inputs consistent with applicable regulatory guidance identified in RG 1.195, RG 1.196, SRP Section 15.1.5, and SRP Section 15.6.3. The other assumptions previously found acceptable to the NRC staff are presented in the WBN Unit 1, UFSAR. The licensee's calculated dose results are given in Table 3.4.2 and Table 3.4.3 of this SE. The NRC staff performed independent confirmatory dose evaluations, as necessary, to ensure a thorough understanding of the licensee's methods. The NRC staff finds, with reasonable assurance, that the licensee's estimates of the dose consequences of a design basis MSLB and SGTR will comply with the requirements of 10 CFR 100.11 and the accident specific dose guidelines specified in RG 1.195, and are, therefore, acceptable.

Table 3.4.2
Radiological Consequences for SGTR

Pre-Accident Spike	Control Room	EAB	LPZ
Whole Body (rem)	8.64E-02	3.50E-01	1.03E-01
Thyroid (rem)	2.29E+01	1.33E+01	3.81E+00

Accident Initiated Spike	Control Room	EAB	LPZ
Whole Body (rem)	8.18E-02	5.05E-01	1.48E-01
Thyroid (rem)	3.61E+00	6.37E+00	1.87E+00

Table 3.4.3
Radiological Consequences for MSLB

Pre-Accident Spike	Control Room	EAB	LPZ
Whole Body (rem)	7.12E-03	2.92E-02	1.16E-02
Thyroid (rem)	1.32E+01	2.63E+00	1.27E+00
Accident Initiated Spike	Control Room	EAB	LPZ
Whole Body (rem)	1.25E-02	1.04E-01	1.23E-01
Thyroid (rem)	1.73E+01	3.20E+00	4.59E+00

3.4.5 Loss of Alternating Current (AC) Power

The environmental consequences of a loss of normal AC power to the plant auxiliaries involves the release of steam from the secondary system. This will not result in a release of radioactivity unless there is leakage from the RCS to the secondary system in the steam generator. The analysis assumes a secondary source term at the TS activity limit of 0.1 µCi/gm of dose equivalent I-131. In addition, the licensee assumed a failure of two TPBARs, which yields an RCS tritium level of 124.9 µCi/gm. The new control room isolation delay time is 74 seconds, which is increased from 40 seconds to 74 seconds to correct an error in how the delay time was determined.

The licensee evaluated the radiological consequences resulting from the postulated loss of AC power event and concluded that the radiological consequences at the EAB, the LPZ, and the control room comply with the reference values provided in 10 CFR 100.11 and 10 CFR Part 50, Appendix A, GDC-19 limits. The NRC staff's review found that the licensee used analyses, assumptions, and inputs consistent with applicable regulatory guidance. The other assumptions previously found acceptable to the NRC staff are presented in the WBN Unit 1, UFSAR. The licensee's calculated dose results are given in Table 3.4.4 of this SE. The NRC staff performed independent confirmatory dose evaluations, as necessary, to ensure a thorough understanding of the licensee's methods. The NRC staff finds, with reasonable assurance, that the licensee's estimates of the dose consequences of a design basis loss of AC power event will comply with the requirements of 10 CFR 100.11 and 10 CFR Part 50, Appendix A, GDC-19 and are, therefore, acceptable.

Table 3.4.4
Radiological Consequences for Loss of AC Power

Realistic	Control Room	EAB	LPZ
Whole Body (rem)	8.04E-09	1.84E-08	1.05E-08
Thyroid (rem)	8.43E-07	1.13E-06	6.46E-07
Conservative	Control Room	EAB	LPZ
Whole Body (rem)	3.34E-04	7.63E-04	4.37E-04
Thyroid (rem)	3.50E-02	4.69E-02	2.68E-02

3.4.6 Waste Gas Decay Tank Rupture

The gaseous waste disposal system (WDS) is designed to remove fission product gases from the reactor coolant. The WDS contains nine gas decay tanks. The tanks receive gaseous waste from the chemical volume and control system (CVCS) holdup tank, CVCS volume control tank, WDS spent resin tank, CVCS boric acid evaporator, and WDS reactor drain tank. The maximum amount of waste gases stored occurs after a refueling shutdown at which time the WGDTs store the radioactive gases stripped from the reactor coolant. The accident is defined as an unexpected and uncontrolled release of radioactive xenon and krypton fission product gases and tritium, in the form of tritium water vapor, stored in a waste decay tank as a consequence of a failure of a single WGDT or associated piping. The tank rupture is assumed to occur immediately upon completion of the waste gas transfer, releasing the entire contents of the tank through the auxiliary building vent to the outside atmosphere. The reactor is assumed to have been operating at full power with 1-percent defective fuel and have two TPBAR failures. In addition, the maximum content of the failed WGDT is assumed to be released to the environment over a 2-hour time period. The new control room isolation delay time is 74 seconds, which is increased from 40 seconds to 74 seconds to correct an error in how the delay time was determined as described in Reference 4.

The licensee evaluated the radiological consequences resulting from the postulated WGDT rupture and concluded that the radiological consequences at the EAB, the LPZ, and the control room comply with the reference values provided in 10 CFR 100.11, 10 CFR Part 50, Appendix A, GDC-19 limits, and the accident specific dose guidelines specified in RG 1.24. The NRC staff's review found that the licensee used analyses, assumptions, and inputs consistent with applicable regulatory guidance identified in RG 1.24. The other assumptions previously found acceptable to the NRC staff are presented in the WBN Unit 1, UFSAR. The licensee's calculated dose results are given in Table 3.4.5 of this SE. The NRC staff performed independent confirmatory dose evaluations as necessary to ensure a thorough understanding of the licensee's methods. The NRC staff finds, with reasonable assurance, that the licensee's estimates of the dose consequences of a postulated WGDT rupture will comply with the requirements of 10 CFR 100.11, 10 CFR Part 50, Appendix A, GDC-19, and the accident specific dose guidelines specified in RG 1.24 and are, therefore, acceptable.

Table 3.4.5
Radiological Consequences for WGDT Rupture

	Control Room	EAB	LPZ
Whole Body (rem)	7.92E-01	5.00E-01	1.40E-01
Thyroid (rem)	1.08E-02	1.29E-02	3.60E-03

3.4.7 Rod Ejection Accident

This accident is defined as the mechanical failure of a control rod mechanism pressure housing resulting in the ejection of a rod cluster control assembly and drive shaft. The consequence of this mechanical failure is a rapid positive reactivity insertion together with an adverse core power distribution, possibly leading to localized fuel rod damage. WBN UFSAR Section 15.4.6, "Rupture of a Control Rod Drive Mechanism Housing (Rod Cluster Control Assembly Ejection)," analyzed this accident and concludes that:

> Even on a worst-case basis, the analyses indicate that the described fuel and clad limits are not exceeded. It is concluded that there is no danger of sudden

> fuel dispersal into the coolant. Since the peak pressure does not exceed that which would cause stresses to exceed the faulted condition stress limits, it is concluded that there is no danger of further, consequential damage to the reactor coolant system. The Reference [16] analyses have demonstrated that the number of fuel rods entering DNB amounts to less than 10%, thus satisfactorily limiting fission product release. The environmental consequences of this accident is bounded by the loss of coolant accident.

In letter dated September 25, 2015 (Reference 6), TVA stated that, as it is discussed in License Amendment No. 40 and UFSAR Chapter 15.5.7, the rod ejection accident is bounded by the LOCA and is not explicitly analyzed. The NRC staff evaluated the control rod ejection accident discussion in UFSAR Section 15.5.7, "Environmental Consequences of a Postulated Rod Ejection Accident," and determined that it does not include a detailed evaluation of this accident except to state that it is bounded by the LOCA. The LOCA dose consequence results for WBN Unit 1 are less than 25 percent of the reference values in 10 CFR 100.11. Since (1) fuel damage is not postulated to occur during the rod ejection accident, (2) the source term for a control rod ejection accident is considerably less than for a LOCA, and (3) the dose consequence results for the WBN Unit 1 LOCA are less than the SRP acceptance criteria for a rod ejection accident (i.e., 25 percent of the reference values in 10 CFR 100.11), the staff concludes that the dose consequence for the rod ejection accident will be bounded by the LOCA for WBN Unit 1 and that the control room isolation delay time does not apply to the rod ejection accident.

3.4.8 Failure of Small Lines Carrying Primary Coolant outside Containment

Failure of small lines carrying primary coolant outside the containment is considered to be ECCS leakage outside containment following a LOCA, which is included as part of the LOCA analysis. As stated above in the Section 3.4.2 LOCA evaluation, the NRC staff has determined that the current licensing basis of 2,304 TPBARs is bounding for the LOCA, which includes ECCS leakage outside containment, because the amount of tritium produced per TPBAR remains the same and the number of TPBARs exceeds that which is requested in this LAR.

In addition, because the control room isolation is initiated directly on a safety injection signal that is initiated by the ESFAS in response to a LOCA, as opposed to the control room radiation monitors, the control room isolation delay time does not apply to LOCA.

3.4.9 Use of Total Effective Dose Equivalent (TEDE)

With the exception of the FHA, the DBA analyses in the Watts Bar licensing basis determined that whole-body and thyroid doses, due to inhalation of radioiodine, are consistent with the criteria in 10 CFR Part 100 and GDC-19. TVA also reported values for the TEDE for informational purposes (References 1, 4, 6, and 11). TVA calculated these TEDE results to appropriately account for the radiological consequences of the increased tritium in the TPC. TVA stated that it does not consider the TEDE results to be the licensing basis for WBN Unit 1; instead, the existing whole-body and thyroid dose calculation methods remain the licensing bases (Reference 4). The NRC staff agrees that tritium is not adequately addressed by the existing whole-body and thyroid dose criteria for two reasons:

- The decay emission energy of tritium is insufficient to penetrate the skin and contribute to the whole-body dose.

- The thyroid dose is explicitly limited to inhalation of radioiodine.

The use of TEDE as a dose quantity addresses these limitations. The NRC staff reviewed the assumptions, inputs, and methods used by TVA to assess the radiological impacts of the proposed TPC operation at WBN Unit 1. In doing this review, the NRC staff relied on information placed on the docket by TVA. The NRC staff finds that TVA used analysis methods and assumptions that are adequately conservative and consistent with applicable regulatory guidance. The NRC staff accepted the TEDE as supplemental information proposed by TVA and compared the doses estimated by TVA to the previous TEDE doses in License Amendment No. 40. The NRC staff continues to find acceptable the estimated TEDE doses as supplemental information proposed by TVA.

3.4.10 Post-Accident Radiological Dose Conclusion

The NRC staff reviewed the assumptions, inputs, and methods used by TVA to assess the radiological impacts of the proposed TS changes and performed independent analyses to confirm the conservatism of TVA's analyses. The NRC staff finds that TVA used analysis methods and assumptions that are adequately conservative and consistent with regulatory guidance, where applicable. The NRC staff also finds, with reasonable assurance, that TVA's estimates of the exclusion area boundary, low-population zone, and control room doses will continue to comply with 10 CFR Part 100, 10 CFR 50.67 and 10 CFR Part 50, Appendix A, GDC-19, and that the proposed changes are, therefore, acceptable from a radiological consequence standpoint.

3.5 Occupational and Public Radiation Doses

The NRC staff conducted its review of the March 31, 2015, proposed amendment (Reference 1) to ascertain what overall effects the proposed increase in the maximum number of TPBARs irradiated per fuel cycle from 704 to 1,792 would have on both occupational and public radiation doses and the licensee's ability to maintain these doses within applicable regulatory limits and ALARA. The NRC staff's review in this section includes an evaluation of the predicted increases in radiation sources and how these increases may affect plant area dose rates, plant radiation zones, and plant area accessibility. The NRC staff also considered the effects of this LAR on plant effluent levels and radioactive waste generation, and any impacts on the resulting offsite radiation doses to members of the public. The NRC's acceptance criteria for occupational and public radiation doses are based on 10 CFR 50.34(b)(3), 10 CFR Part 20, 10 CFR Part 50, Appendix I, and NUREG-0800 Chapters 11 and 12.

3.5.1 Radioactive Source Terms

Consistent with the criteria in NUREG-0800 Chapter 12, "Radiation Protection," the March 2015 proposed amendment describes two radioactive source terms used in evaluating the radiological impact on normal operations, and AOOs, of increasing the number of TPBARs loaded into the reactor core. The first of these is the design basis source term. The design basis source term assumes the maximum allowable (per WBN Unit 1 TSs) release of radioactive material from the core to the reactor coolant due to reactor operations with fuel defects. The design basis source term is used to evaluate the adequacy of plant design features such as shielding, ventilation, and radwaste system processing capacities. This LAR initially assumed that the contribution to the design basis source term of tritium permeating from the TPBARs would be 10 Ci/year/TPBAR. Following a request for information from the staff, TVA supplemented the LAR, by the letter dated March 2016 (Reference 11), to revise the design basis source term from the assumed 10 Ci/year/TPBAR to an assumed 5 Ci/year/TPBAR (with an assumed 1,900 TPBAR core loading). This revised assumption is still bounding of the 3.4 Ci/year/TPBAR average tritium release measured during recent TPBAR operations. The second source term is used to evaluate the plant effluents against the design criteria in 10 CFR Part 50, Appendix I. This "realistic source term" is based on industry experience, consistent with NUREG-0800 and the guidance in ANSI 18.1, "Source Term Specifications." The realistic source term does not assume maximum technical specification fuel leakage. TVA's realistic source term also conservatively assumes a tritium contribution from TPBAR operations of 5 Ci /year/TPBAR and 1,900 TPBARs loaded in the core.

The safety analysis submitted to support Amendment No. 40, includes a tritium release from two failed TPBARs as an AOO. However, in the safety analysis submitted with the March 2015 LAR, TVA notes that the likelihood of two failed TPBARs is such that it would not be expected during the life of the plant. Therefore, such a failure is not an AOO as defined in 10 CFR Part 50, Appendix A, and was not included in the normal operating design basis source term in the proposed amendment.

3.5.2 Occupational Dose

Occupational radiation dose resulting from the exposure to tritium during TPBAR operations was not extensively evaluated in the DOE Topical Report (Reference 12) and NUREG-1672 (Reference 13). Instead, DOE noted that operating experience for U.S. Pressurized-Water Reactors indicated that there were no significant occupational tritium exposure issues related to plant operations and maintenance if the tritium concentration in the RCS water was maintained below 3.5 μCi/gm. A focus of the Topical Report was to verify that the radwaste processing system is capable of processing the volumes of make-up and let-down water necessary to maintain reactor coolant below this "tritium control level." However, it did not anticipate any increase in reactor water make-up, other than what is currently needed for reactor coolant boron control. With the assumption of routine make-up for boron control and 1,900 TPBARs at 5 Ci/year/TPBAR, TVA estimated that the RCS tritium concentration could be as high as 12 μCi/gm. Therefore, in lieu of maintaining the reactor coolant below the tritium control level assumed in the topical report, the March 2015 LAR addresses the expected impacts of the requested increased tritium production on occupational radiation doses. These include possible increases in airborne contamination within the plant, direct external occupational exposure due to fuel and TPBAR handling activities, and occupational radiation dose from working around open water systems with high tritium concentrations.

TVA assessed the impact of operating with the proposed increased number of TPBARs on in-plant airborne radioactivity due to normal leakage from systems containing reactor coolant. As a bounding case, TVA calculated the expected airborne concentrations in the reactor containment in terms of a "DAC-Fraction" (i.e., the sum of the airborne isotopic concentration divided by the respective derived air concentrations (DACs) listed in Appendix B to 10 CFR Part 20). The DAC-Fraction in containment was obtained by multiplying the average DAC-fraction measured in containment during recent TPBAR operations (0.08) by the ratio of the revised design basis concentration (12 μCi/gm) to the average RCS tritium concentration (1.0 μCi/gm) experienced in the same timeframe. The resulting DAC-Fraction (0.96) is less than 1.0. Therefore, this (bounding) area would not be required to be continuously controlled as an airborne radioactivity area per the requirements of 10 CFR 20.1702. See the example DAC calculation for multiple isotopes in the footnotes to 10 CFR Part 20, Appendix B.

TVA also assessed the impact of collective occupational dose from routine intakes during normal operations. To estimate the increase on the collective Committed Effective Dose Equivalent (CEDE) of the entire workforce, TVA adjusted the average annual CEDE experienced during recent TPBAR operations (2.0 person-rem CEDE), by the ratio of the average RCS tritium concentration to the calculated design basis RCS concentrations. The result is an additional 24 person-rem/yr
(2.0 person-rem/yr * 12 μCi/gm /1 μCi/gm = 24 person-rem/yr CEDE) from TPBAR-related airborne tritium.

Additionally, TVA estimated the occupational dose received due to fuel and TPBAR handling activities. TVA's current estimate of the TPBAR cycle work scope includes pre-cycle preparation activities, post-cycle hardware removal and handling activities, TPBAR consolidation (including equipment setup and disassembly), shipping activities, and the processing, packaging, and shipping of the irradiated components. Based on actual dose accrual, the average dose for these activities is 0.46 mrem/TPBAR. Conservatively rounding this result up to 1 mrem/TPBAR, and applying the design basis source term assumption of a 1,900 TPBAR core, results in an additional 1.3 person-rem/year TEDE (1.9 rem per 18-month fuel cycle) for TPBAR handling and consolidation activities.

Therefore, TVA estimates an additional 25.3 person rem/year expected from WBN Unit 1 TPBAR operations under the design basis source term conditions. Adding this value to the average occupational collective dose of 40 person-rem for 2010 to 2013 (reported in NUREG-0713, Vol. 34), TVA calculated a total estimate of 65.3 person-rem for operating WBN Unit 1 at the proposed design basis source term conditions.

Based on the above, the NRC staff finds that there is reasonable assurance that WBN Unit 1 can be operated at or below the current licensing basis criteria of 100 person-rem average annual collective dose while operating with the proposed maximum core loading of 1,792 TPBARs and, therefore, such operation is acceptable.

Notwithstanding these estimated impacts on collective occupational dose, tritium uptakes and resulting doses for individual workers can be significant as they are exposed to open systems of tritium contaminated water (e.g., reactor coolant) during reactor operations and system maintenance. To ensure that individual occupational doses are maintained ALARA, TVA has implemented a "Radiation Production Tritium Control Program," as described in Reference 11. Additional procedural requirements addressing enhanced tritium survey and monitoring capabilities are integrated into the WBN Radiation Protection Program. Table 3.5.1 summarizes the action levels incorporated into the program. TVA's program establishes criteria for performing in vitro bioassay: (1) based on process water concentrations, (2) for exposures greater than or equal to 4 DAC-hours (hrs) in seven consecutive days, and (3) for cases of skin contact with water exceeding 0.01 μCi/ml of tritium. Tritium DAC-hr tracking is initiated whenever a worker is exposed to concentrations of 0.3 DAC or greater. TVA procedures cover (1) types of appropriate bioassay, (2) selection of individuals for bioassay, (3) bioassay collection, (4) sample volume, storage, packaging, and shipping, (5) analytical equipment detection limits, and (6) internal dose calculation methods. TVA's program requires a Minimum Detectable Activity (MDA) of less than 1E+04 pCi/L (i.e., 0.01 μCi/L) tritium for urine bioassays. This MDA is less than the 0.3 μCi/L detection criteria specified in ANSI N13.14.

Table 3.5.1
WBN Radiation Production Tritium Control Program (Reference 11)

TRITIUM ACTION LEVELS					
Process Tritium Concentration (µCi/ml)	**DAC, DAC-hrs**	**Mode of Exposure**	**Tritium Survey Requirements**	**Action**	**Basis for Bioassay (Regulatory guidance and TVA Procedure Requirements)**
≥ 0.01	N/A	direct contact	measurement of process water	Urinalysis following skin contact, ingestion, or absorption through cuts or abrasions. Diving requires routine bioassays as specified in Note 1.	US NRC Regulatory Guide 8.32
≥ 10.0		inhalation	measurement of process water and tritium air samples	Urinalysis following exposure to air in a room whenever employees are exposed to greater than 10 kg of water containing 0.01 Ci/kg or when water containing a total of more than 0.1 Ci of tritium is in contact with air (such as a fuel pool).	US NRC Regulatory Guide 8.32
	≥ 0.3 DAC	inhalation	tritium air samples	Urinalysis recommended, see Note 2	
	≥ 4 DAC-hrs in 7 consec utive days	inhalation	tritium air samples with DAC-hr tracking	Urinalysis	Based on 10 mrem/week, which is easily detected and verified by bioassay.

Note 1
Underwater diving operations in tritiated water exceeding 0.01µCi/ml, collection and analysis of urine samples for each diver: (a) prior to the first on-site dive, (b) within 24 hours following the completion of the initial dive, (c) once each week while diving operations are in progress, (d) upon completion of diving operations, and (e) whenever diving suit leakage results in skin contact with tritiated water.

Note 2
Work activities where employees are known or may be exposed to tritium atmospheres exceeding 0.3 DAC: (a) pre-job urine samples to establish a baseline value, (b) collection and analysis of urine within 24 hours following the completion of the first exposure, (c) weekly to ten days for the duration of the work involving tritium exposure, and (d) upon completion of the work involving tritium exposure.

The frequency of bioassays is determined based on the kind of work to be performed, the expected exposure scenario, and program trigger levels. Baseline tritium bioassays are obtained for all divers prior to the first on-site dive. Baseline (pre-job) tritium bioassays are also required for work activities where workers are known or may be exposed to tritium atmospheres exceeding the trigger level of 0.3 DAC. All data (i.e., bioassay, air samples with DAC-hr tracking, and whole body counts) are reviewed and evaluated to arrive at the best estimate of the worker's intake and CEDE. In some cases, a single bioassay is enough to evaluate the exposure, in other cases multiple bioassays are obtained (e.g., for work in tritium airborne conditions that may continue for days or weeks). Sample collection guidance for tritium includes collecting urine samples no sooner than 2 hours following the tritium exposure event to allow the activity to equilibrate, and where possible, no later than 72 hours following an acute exposure. The first voiding of the bladder following the exposure is not used for the urinalysis to avoid dilution by pre-exposure volume.

The NRC staff finds that, based on the description of the Radiation Production Tritium Control Program in Reference 11, TVA has sufficient tritium survey and monitoring capabilities to provide reasonable assurance that occupational doses at WBN Unit 1 can be maintained within the limits of 10 CFR Part 20 and ALARA. The staff also finds that the bioassay action levels incorporated into the control program are consistent with the applicable guidance in RG 8.32, "Criteria for Establishing a Tritium Bioassay Program," and ANSI N13.14, "Internal Dosimetry Programs for Tritium Exposure - Minimum Requirements," and are, therefore, acceptable.

3.5.3 Public Dose

To determine whether these design basis effluent activities are within the limits of 10 CFR Part 20, the sum of the ratios of each isotope concentration (C) to its corresponding Effluent Concentration Limit (ECL as listed in 10 CFR Part 20, Appendix B, Table 2, Columns 1 and 2 for gaseous and liquids, respectively) were calculated by the licensee. Consistent with the requirements of 10 CFR 20.1302(b)(2)(i), a C/ECL sum of less than 1.0 indicates that the annual average effluent release is within the limits of 10 CFR 20.1301. Ninety percent of the tritium released into the reactor coolant, under the revised design basis source term assumptions, is assumed to be released from the plant as liquid effluent. Ten percent of the tritium is assumed to be released as gaseous effluent, resulting from in-plant airborne tritium.

Tables 5 through 7, contained in the LAR, present the results of the C/ECL calculations for liquid effluent. These tables contain the isotopic breakdown of the expected annual liquid effluent releases based on the design basis source term assumptions discussed above. Table 5 indicates that extended effluent releases, without processing the condensate demineralizer regeneration waste through the Mobile Demineralizer, will not meet the limits of 10 CFR Part 20 and is not acceptable. To insure that the effluent concentration limits of 10 CFR Part 20 are met, the condensate regeneration waste is rerouted through the Mobile Demineralizers if the long term releases of untreated condensate regeneration waste would be greater than the 10 CFR Part 20 concentration limits. Tables 6 and 7 indicate that under full design basis conditions, extended treated liquid effluent releases (i.e., condensate demineralizer regeneration waste through the Mobile Demineralizer) will be maintained within the 10 CFR Part 20, Appendix B, Table 2, Column 2 concentration limits. Tables 8 and 9 in the LAR demonstrate that under TPBAR revised design basis source term assumptions, gaseous effluent releases will be maintained within the 10 CFR Part 20, Appendix B, Table 2, Column 1 concentration limits. This is consistent with the original design basis of the Watts Bar Radwaste Processing System.

The staff finds that TVA has demonstrated that WBN Unit 1 can be operated with the proposed maximum core loading of 1,792 TPBARs, and maintain the gaseous and liquid effluents within the Effluent Concentration Limits listed in 10 CFR Part 20 Appendix B, and, therefore, such operation is acceptable.

3.5.4 10 CFR Part 50, Appendix I - ALARA

To evaluate the expected impact on public doses from plant operations with the proposed TPBAR loading, TVA calculated bounding public doses from the applicable plant effluent dose pathways, with and without the tritium release attributable to TPBAR permeability. These doses were based on the realistic source term discussed above and the methods and assumptions in the current WBN Offsite Dose Calculation Manual (documented in the "Watts Bar Nuclear Plant Unit 1, Annual Radioactive Effluent Release Report – 2014," Reference 26). Table 3.5.2 summarizes the results of the licensee's calculations. Each of the doses remain well within the applicable ALARA design criteria of 10 CFR Part 50, Appendix I, and are, therefore, acceptable.

Table 3.5.2

Impacts of Increased TPBAR Operations Per the Effluent ALARA Design Criteria In 10 CFR Part 50 Appendix I

	Non-TPC Realistic Dose	**TPC Realistic Dose**	**Incremental Increase from TPC**	**NRC Annual Effluent Exposure Guideline**
Annual Radioactive Gaseous Emissions				
Maximally Exposed Individual (mrem)	0.55	0.55	0	5.00 Whole Body
Maximally Exposed Individual (mrem)	8.8 (Bone) See Note 1	10.6 (Bone)	1.8	15.00 Organ
50-mile Population Dose (Rem)	7.01 (Bone)	10.7 (Bone)	3.69	NA
Annual Radioactive Liquid Emissions				
Maximally Exposed Individual (mrem)	0.40	0.43	0.03	3.00 Whole Body
Maximally Exposed Individual (mrem)	0.55 (Liver)	0.57 (Liver)	0.02	10.00 Organ
50-mile Population Dose (Rem)	3.6 (Thyroid)	6.7 (Thyroid)	3.1	NA

Note 1 - With the inclusion of Carbon-14, as required by Revision 2 of RG 1.21, Bone became the critical organ.

The staff finds that, based on the bounding calculations provided in this LAR, operation with the proposed increased TPBAR loading will have a minimal impact on the expected public radiation exposures, and that the resulting doses will remain well within the applicable ALARA design criteria of 10 CFR Part 50, Appendix I, and, therefore, such operation is acceptable.

3.5.5 Tritium Leak and Spills

Extended WBN Unit 1 operations at design basis conditions, with tritium concentrations in the reactor coolant up to 12 μCi/gm, presents an increased potential for contaminating (1) the plant site, from liquid leaks and spills, or (2) plant systems that were not anticipated or designed to contain radioactive materials. In response to questions from the staff, TVA provided additional assurance that unintended contamination of site groundwater or non-radioactive plant systems will not go undetected.

TVA has committed to the industry initiative described in NEI 07-07, "Ground Water Protection Initiative" (GPI) (Reference 27), for WBN Unit 1 as documented in UFSAR Section 1.1.3. The GPI includes provisions for a routine groundwater monitoring program, including tritium, in subsurface soils and water. The GPI defines actions to manage and respond to instances where the inadvertent release, i.e., spills and leaks, from plant systems could result in detectible levels of licensed radioactive materials in soils or ground water. The most recent results of the TVA groundwater monitoring program were provided to the NRC in "Watts Bar Nuclear Plant Unit 1 Annual Radioactive Effluent Release Report – 2014" (Reference 26).

NRC Information Bulletin 80-10 (Reference 28) alerted licensees to the hazards of contaminating plant systems that were not designed to contain licensed radioactive materials. The bulletin requested licensees to establish a routine sampling/analysis or monitoring program for systems considered as nonradioactive (or described as nonradioactive in the UFSAR), but could possibly become radioactive through interfaces with radioactive systems. The goal of this enhanced monitoring is to promptly identify any contaminating events that could lead to unmonitored, uncontrolled liquid or gaseous releases to the environment, including releases to on-site leaching fields or retention ponds. In the December 22, 2015, response to the staff's RAI, TVA described WBN procedures that provide routine monitoring of non-radioactive systems such as the Auxiliary Boiler, Raw Water Cooling, Potable Water, as well as the Yard Holding and Low Volume Waste Treatment Ponds.

Based on the above response, the staff finds that there is reasonable assurance that WBN programs will minimize the potential for site contamination and, per the requirements of 10 CFR 20.1406(c), assure that non-radioactive systems will not unintentionally become contaminated. The staff finds that there is reasonable assurance that plant systems and areas will be properly surveyed and monitored per the requirements in 10 CFR 20.1501, and, therefore, finds the WBN programs acceptable with respect to operations with 1,792 TPBARs loaded in the core.

3.5.6 Solid Radwaste

During normal TPC operations, and consolidation activities, additional solid waste in the form of the base plate and thimble plug assemblies will be generated. In the proposed amendment, TVA notes that the environmental impact from the solid radioactive waste associated with plant operations with 1,792 TPBARs per refueling cycle, is bounded by the WBN Unit 1 License Amendment No. 40 environmental impact assessed at 2,304 TPBARs.

The staff finds that the increase in solid radioactive waste and the environmental impacts of the proposed amendment are bounded by the WBN Unit 1 License Amendment No. 40 impact assessment previously approved by the NRC and are, therefore, acceptable. An Environmental Assessment and Finding of No Significant Impact was published on July 5, 2016. The

Environmental considerations of the proposed amendment are discussed further in Section 5.0 of this SE.

3.5.7 Radiological Protection Conclusion

The staff concludes that, based on the considerations discussed above, there is reasonable assurance that routine operations of WBN Unit 1 with a maximum TPBAR loading of 1,792 TPBARs per cycle, will be within the dose limits for members of the public and occupational workers in 10 CFR Part 20 and ALARA. Therefore, the proposed license amendment, as supplemented, is acceptable.

3.6 Technical Specification Changes

The licensee is requesting three TS changes. The first TS change would increase the maximum number of TPBARs allowed for loading into the WBN Unit 1 core from 704 to 1,792. The information submitted by the licensee, as evaluated by the NRC staff in Sections 3.1 through 3.3, demonstrates that all applicable regulatory requirements are met for this change.

The other two requested TS changes would remove outdated information from the SRs for boron concentration in the CLAs and RWST (TS SR 3.5.1.4, "Accumulators," and TS SR 3.5.4.3 "RWST," respectively). In the current and previous versions of these SRs, a table has been included to provide a range of the number of TPBARs loaded in the core and the corresponding required CLA/RWST boron concentrations. The operator has been responsible for consulting the COLR to identify the number of TPBARs currently loaded in the core, then cross-referencing that information with the tables to determine the required boron concentrations. During the entire time that WBN Unit 1 has been producing tritium, however, these tables have consisted of a single range, from zero TPBARs to the maximum allowed number of TPBARs, and a single set of corresponding CLA/RWST boron concentrations.

The purpose of these SRs is to assure that the LCOs of the RWST and accumulators will be maintained by periodically verifying that their boron concentrations are within the designated ranges required by the analyses supporting the number of TPBARs loaded in the core. The boron concentration ranges specified in the TS remain unchanged by the proposed amendment.

The proposed changes to the SRs simplify the SRs by removing the tables and providing, instead, a single range for each required boron concentration, without any reference to the number of TPBARs currently loaded in the core. Since the maximum number of TPBARs is established elsewhere in the TS and the boron concentrations being given are valid for any TPBAR loading up to the maximum number allowed, the NRC staff finds the proposed changes to be acceptable. The proposed TS SRs 3.5.1.4 and 3.5.4.3 are acceptable and meet the requirements of 10 CFR 50.36(c)(3) to ensure that the necessary quality of the systems is maintained.

As a result of the above evaluations, the NRC staff finds all of the proposed TS changes to be acceptable and consistent with all applicable regulatory requirements.

3.7 Technical Evaluation Conclusion

The NRC staff finds that the new operating and accident conditions associated with the licensee's proposed increase in the maximum number of TPBARs allowed to be loaded in the WBN Unit 1 core were analyzed through the appropriate use of NRC-approved methodologies in accordance with NRC guidelines. The NRC staff further finds that the licensee used methods consistent with the regulatory requirements and guidance identified in Section 2.0 above. The LAR also proposed the removal from the TS of outdated information, which information the NRC staff confirmed as being unnecessary under applicable NRC regulations.

Based on a review of the proposed amendment and supporting analysis as supplemented (References 1 through 11), the NRC staff concludes that reasonable assurance exists that the WBN Unit 1 core will, with the proposed TS modifications and proposed license condition, continue to meet the applicable regulatory requirements.

4.0 REGULATORY COMMITMENTS

In Enclosure 6 of Reference 11, the licensee provided an updated list of Regulatory Commitments that supersedes the previous commitment lists provided in References 1, 5, 8, and 10.

Reference 10 included a commitment to revise RCI-137, "Radiation Production Tritium Control Program," Table 3.1, "Tritium Action Levels," to incorporate criteria from NRC Regulatory Guide (RG) 8.32, "Criteria for Establishing a Tritium Bioassay Program."

In References 1, 5, 8, and 10, the licensee committed to replace containment isolation thermal relief check valves on the WBN Unit 1 Component Cooling System (CCS) and Essential Raw Cooling Water (ERCW) System (Commitment 1). In Reference 11, the licensee confirmed that the replacement of the subject thermal relief check valves had occurred. Therefore, Commitment 1 was deleted from the Commitment List (Enclosure 6 of Reference 11).

5.0 LICENSE CONDITION

Enclosure 5 of Reference 11 contains a proposed license condition requiring replacement of the WBN Unit 1 upper compartment cooler cooling coils before TPBAR loading can be increased past 704 TPBARs per core. This condition would be 2.C.(11) in the amended Facility Operating License.

This license condition to replace the upper compartment cooler cooling coils with safety-related cooling coils is necessary to ensure the acceptability of the proposed changes. In Reference 11, the licensee confirmed that the check valves discussed in the LAR were replaced during the previous refueling outage and provided a proposed license condition to ensure that the cooling coils will be replaced prior to increasing the TPBAR loading above the current limit of 704 TPBARs. This license condition will be imposed by amendment to Facility Operating License No. NPF-90, concurrent with the granting of the proposed amendment.

6.0 RECOMMENDED AREAS FOR INSPECTION

As described above, the NRC staff conducted a review of the licensee's proposed increase in TPBARs loaded in the WBN Unit 1 core. The NRC staff identified the following areas for consideration by the NRC inspection staff during the licensee's implementation of the proposed TPBAR loading increase:

- While the methodology evaluated by the NRC staff in the analyses submitted for review was found to be acceptable, the staff notes that this approval is based on a representative core design with a maximum of 1,792 TPBARs loaded. The actual number of TPBARs loaded will be determined by the licensee for each cycle and the licensee must continue to check, pursuant to the WBN Unit 1 TS, that applicable assumptions in the post-LOCA criticality assessment described in Section 3.1.3.1 remain valid for each specific core loaded with TPBARs at WBN Unit 1.

- The License Condition 2.C.(11) must be met before the licensee increases TPBAR loading above 704.
- All relevant procedures affected by the elimination of operator actions described in Section 3.3 should be updated upon implementation. In Reference 3, the licensee identified that changes to Emergency Operating Instruction 1-E-0, "Reactor Trip of Safety Injection," Revision 5, to remove the above described operator manual actions, will be necessary.

7.0 STATE CONSULTATION

In accordance with the Commission's regulations, the Tennessee State official was notified of the proposed issuance of the amendment on June 30, 2016. The State official had no comments.

8.0 ENVIRONMENTAL CONSIDERATION

Pursuant to 10 CFR 51.21, 51.32, and 51.35, an environmental assessment and finding of no significant impact regarding this license amendment was published in the *Federal Register* on July 5, 2016 (81 FR 43656). Based upon the environmental assessment, the Commission has determined that issuance of this amendment will not have a significant effect on the quality of the human environment.

9.0 CONCLUSION

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

10.0 REFERENCES

1. Letter from TVA, CNL-15-001, J. W. Shea, Vice President, Nuclear Licensing, to NRC Document Control Desk, re: "Application to Revise Technical Specification 4.2.1, 'Fuel Assemblies,' (WBN-TS-15-03)," March 31, 2015 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15098A446).

2. Letter from TVA, CNL-15-077, J. W. Shea, Vice President, Nuclear Licensing, to NRC Document Control Desk, re: "Correction to Application to Revise Technical Specification 4.2.1, 'Fuel Assemblies' (WBN-TS-15-03)," dated April 28, 2015 (ADAMS Accession No. ML15124A334).

3. Letter from TVA, CNL-15-092, J. W. Shea, Vice President, Nuclear Licensing, to NRC Document Control Desk, re: "Response to NRC Request to Supplement the Application to Revise Technical Specification 4.2.1, 'Fuel Assemblies' (WBN-TS-15-03)," May 27, 2015 (ADAMS Accession No. ML15147A611).

4. Letter from TVA, CNL-15-093, J. W. Shea, Vice President, Nuclear Licensing, to NRC Document Control Desk, re: "Response to NRC Request to Supplement Application to Revise Technical Specification 4.2.1, 'Fuel Assemblies' (WBN-TS-15-03)," June 15, 2015 (ADAMS Accession No. Accession No. ML15167A359).

5. Letter from TVA, CNL-15-172, J. W. Shea, Vice President, Nuclear Licensing, to NRC Document Control Desk, re: "Application to Revise Technical Specification 4.2.1, 'Fuel Assemblies' (WBN-TS-15-03) (TAC No. MF6050) – Response to NRC Request for Additional Information – Reactor Systems Branch," September 14, 2015 (ADAMS Accession No. ML15258A204).

6. Letter from TVA, CNL-15-192, J. W. Shea, Vice President, Nuclear Licensing, to NRC Document Control Desk, re: "Application to Revise Technical Specification 4.2.1, 'Fuel Assemblies' (WBN-TS-15-03) (TAC No. MF6050) – Response to NRC Request for Additional Information – Radiation Protection and Consequence Branch," September 25, 2015 (ADAMS Accession No. ML15268A568).

7. Letter from TVA, CNL-15-232, J. W. Shea, Vice President, Nuclear Licensing, to NRC Document Control Desk, re: "Application to Revise Technical Specification 4.2.1, 'Fuel Assemblies' (WBN-TS-15-03) (TAC No. MF6050) – Response to NRC Request for Additional Information – Nuclear Performance and Code Review Branch," November 30, 2015 (ADAMS Accession No. ML15335A468).

8. Letter from TVA, CNL-15-216, J. W. Shea, Vice President, Nuclear Licensing, to NRC Document Control Desk, re: "Application to Revise Technical Specification 4.2.1, 'Fuel Assemblies' (WBN-TS-15-03) (TAC No. MF6050) - Response to NRC Request for Additional Information - Radiation Protection and Consequence Branch," December 22, 2015 (ADAMS Accession No. ML16054A661).

9. Letter from TVA, CNL-15-263, J. W. Shea, Vice President, Nuclear Licensing, to NRC Document Control Desk, re: "Application to Revise Technical Specification 4.2.1, 'Fuel Assemblies,' (WBN-TS-15-03) (TAC No. MF6050) – Supplemental Information Related to the Onsite Regulatory Audit at Pacific Northwest National Laboratory," December 29, 2015 (ADAMS Accession No. ML16004A161).

10. Letter from TVA, CNL-16-030, J. W. Shea, Vice President, Nuclear Licensing, to NRC Document Control Desk, re: "Application to Revise Technical Specification 4.2.1, 'Fuel Assemblies' (WBN-TS-15-03) (TAC No. MF6050) - Supplement to Response to NRC Request for Additional Information - Radiation Protection and Consequence Branch," February 22, 2016 (ADAMS Accession No. ML16053A513).

11. Letter from TVA, CNL-16-038, J. W. Shea, Vice President, Nuclear Licensing, to NRC Document Control Desk, re: "Application to Revise Technical Specification 4.2.1, 'Fuel Assemblies' (WBN-TS-15-03) (TAC No. MF6050) – Radioactive Waste System Design Basis Source Term Supplement to Response to NRC Request for Additional Information – Radiation Protection and Consequence Branch," March 31, 2016 (ADAMS Accession No. ML16095A064).

12. NDP-98-181, Revision 1, "Tritium Production Core (TPC) Topical Report," Westinghouse Electric Company, Unclassified, Non-proprietary version, February 8, 1999 (ADAMS Accession No. ML16077A093).

13. NRC Report NUREG-1672, "Safety Evaluation Report Related to the Department of Energy's Topical Report on the Tritium Production Core," May 1999 (ADAMS Accession No. 9907210095).

14. NRC letter to TVA, "Watts Bar Nuclear Plant, Unit 1 – Issuance of Amendment to Irradiate Up to 2304 Tritium-Producing Burnable Absorber Rods in the Reactor Core (TAC No. MB1884)," September 23, 2002 (ADAMS Accession No. ML022540925). Amendment No. 40.

15. NRC letter to TVA, "Watts Bar Nuclear Plant, Unit 1 – Issuance of Amendment Regarding Revision of Boron Requirements for Cold Leg Accumulators and Refueling Water Storage Tank (TAC No. MB9480)," October 8, 2003 (ADAMS Accession No. ML032880062). Amendment No. 48.

16. NRC Letter to TVA, "Watts Bar Nuclear Plant, Unit 1 - Issuance of an Amendment to Revise the Updated Final Safety Analysis Report Failure Modes and Effects Analysis - Use of Operator Action (TAC NO. MB8102)," March 29, 2004 (ADAMS Accession No. ML040900172). Amendment 51.

17. NRC letter to TVA, "Watts Bar Nuclear Plant, Unit 1 – Issuance of Amendment Regarding the Maximum Number of Tritium Producing Burnable Assembly Rods in the Reactor Core (TAC No. MD5430)," January 18, 2008 (ADAMS Accession No. ML073520546). Amendment No. 67.

18. NRC letter to TVA, "Watts Bar Nuclear Plant, Unit 1 – Issuance of Amendment Regarding the Maximum Number of Tritium Producing Burnable Assembly Rods in the Reactor Core (TAC No. MD9396)," May 4, 2009 (ADAMS Accession No. ML090920506). Amendment No. 77.

19. NDP-00-0344, Revision 1, "Implementation and Utilization of Tritium Producing Burnable Absorber Rods (TPBARs) in Watts Bar Unit 1," Westinghouse Electric Company, July 2001 (ADAMS Accession No. ML012390106, Enclosure 4).

20. LTR-NRC-12-18, "Westinghouse Response to December 16, 2011 NRC Letter Regarding Nuclear Fuel Thermal Conductivity Degradation," Westinghouse, February 17, 2012 (ADAMS Accession No. ML12053A105).

21. Appendix A, "Westinghouse Customer Letter Regarding Thermal Conductivity Degradation LTR-RC-11-688, NRC Information Notice (IN 2011-21)," Westinghouse Proprietary Response to the NRC Letter, dated December 16, 2011, Regarding Nuclear Fuel Thermal Conductivity Degradation February 17, 2012 (ADAMS Accession No. ML12054A250, non-public).

22. WCAP-9272-P-A, "Westinghouse Reload Safety Evaluation Methodology," Westinghouse, July 1995.

23. NRC letter to TVA, "Watts Bar Nuclear Plant, Unit 1 – Issuance of Amendment Regarding Technical Specification Changes in Dose Equivalent I-131 Spike Limit and Allowable Value for Control Room Air Intake Radiation Monitors (TAC No. ME8156)," December 5, 2012 (ADAMS Accession No. ML12279A115). Amendment No. 91.

24. NRC letter to TVA, "Watts Bar Nuclear Plant, Unit 1 – Issuance of Amendment to Allow Selective Implementation of Alternate Source Term to Analyze the Dose Consequences Associated with Fuel-Handling Accidents (TAC No. ME8877)," June 19, 2013 (ADAMS Accession No. ML13141A564). Amendment No. 92.

25. WCAP-16760-NP, "Analysis of Capsule Z from the Tennessee Valley Authority, Watts Bar Unit 1 Reactor Vessel Radiation Surveillance Program," Westinghouse, November 2007 (ADAMS Accession No. ML073200244).

26. WBN Offsite Dose Calculation Manual, as documented in the "Watts Bar Nuclear Plant Unit 1, Annual Radioactive Effluent Release Report - 2014" (ADAMS Accession No. ML15121A826).

27. NEI 07-07, "Industry Ground Water Protection Initiative," August 2007, Nuclear Energy Institute (ADAMS Accession No. ML072610036).

28. NRC IE BULLETIN 80-10, "Contamination of Nonradioactive System and Resulting Potential for Unmonitored, Uncontrolled Release of Radioactivity to Environment," May 6, 1980 (http://www.nrc.gov/reading-rm/doc-collections/gen-comm/bulletins/1980/bl80010.html).

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Date: July 29, 2016

LIST OF ACRONYMS

AC	alternating current
ADAMS	Agencywide Document and Access Management System
AOO	anticipated operational occurrence
ANSI	American National Standards Institute
APRM	average power range monitors
ARCB	radiation protection and consequence branch
ALARA	as low as is reasonably achievable
ANSI	American National Standards Institute
APHB	PRA Operations and Human Factors Branch
ASME	American Society of Mechanical Engineers
B-10	boron 10
PWR	pressurized-water reactor
BPRA	burnable poison rod assemblies
BWRVIP	Boiling-Water Reactor Vessel and Internals Project
CCS	component cooling system
CEDE	committed effective dose equivalent
C/ECL	Concentration per Effluent Concentration Limit
CFR	Code of Federal Regulations
Ci	Curie
CLA	cold-leg accumulator
COLR	core operating limits report
cpm	counts per minute
DAC	derived air concentration
DBA	design-basis accident
DBLOCA	design-basis loss-of-coolant accident
DOE	Department of Energy
DNB	departure from nucleate boiling
EAB	exclusion area boundary

ECCS	emergency core cooling system
ECL	Effluent Concentration Limit
EPA	Environmental Protection Agency
ERCW	essential raw cooling water system
ESFAS	engineered safety feature actuation system
FGR	fission gas release [NOT FEDERAL GUIDANCE REPORT]
FHA	fuel-handling accident
FR	Federal Register
GDC	general design criterion / criteria
gpm	gallons per minute
HELB	high energy line break
HLSO	hot leg switchover
HRA	human reliability analysis
hrs	hours
HSI	human-system interface
I-131	iodine 131
IFBA	integrated fuel burnable absorbers
LAR	license amendment request
LCO	limiting condition of operation
Li-6	lithium 6
LOCA	loss-of-coolant accident
LOOP	loss of offsite power
LPZ	low population zone
LWR	light water reactor
MDA	minimal detectable activity
mrem	millirem
MSLB	main steam line break
NEI	Nuclear Energy Institute
NRC	Nuclear Regulatory Commission
NUREG	NRC technical report
PNNL	Pacific Northwest National Laboratories

ppm	parts per million
PRA	probabilistic risk analysis
psia	pounds per square inch absolute
RAI	request for additional information
RCS	reactor coolant system
rem	roentgen equivalent man
RG	Regulatory Guide
RIP	rod internal pressure
RWST	reactor water storage tank
SE	safety evaluation
SNPB	nuclear code and performance branch
SR	surveillance requirement
SRP	Standard Review Plan
SSC	Structure, system, and component
SGTR	steam generator tube rupture
Sv	Sievert
TEDE	total effective dose equivalent
TPBAR	tritium producing burnable absorber rod
TCD	thermal conductivity degradation
TPC	tritium production core
TR	topical report
TS	technical specification
TVA	Tennessee Valley Authority
U-235	uranium 235
UFSAR	updated final safety analysis report
WBN	Watts Bar Nuclear Plant
WGDT	waste gas decay tank
μC	micro-Curie
μCi/gm	micro-Curie per gram

The NRC staff has determined that its safety evaluation (SE) tor the subject amendment contains proprietary information pursuant to Title 10 of the *Code of Federal Regulations*, Section 2.390. Accordingly, the NRC staff has prepared a redacted, publicly available, non-proprietary version of the SE. Both versions of the SE are enclosed. Notice of Issuance will be included in the Commission's *Federal Register* notice.

If you have any questions regarding this letter, please contact me at (301) 415-1349.

Sincerely,

/RA/

Jeanne Dion, Project Manager
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-390

Enclosures:
1. Amendment No. 107 to NPF-90
2. Non-Propriety Safety Evaluation
3. Proprietary Safety Evaluation

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ADAMS Accession No.: ML16159A057 ***via e-mail dated **via memo dated**

OFFICE	NRR/DORL/LPL3-2/PM	NRR/DORL/LPL2-2/LA	NRR/DRA/APHB/BC(A)
NAME	JDion	BClayton	SLyons*
DATE	7/06/2016	7/19/2016	6/30/2016
OFFICE	NRR/DSS/SNPB/BC	NRR/DRA/ARCB/BC	NRR/DSS/STSB/BC
NAME	JDean*	UShoop**	AKlein
DATE	6/28/2016	5/04/2016	6/23/2016
OFFICE	OGC	NRR/DORL/LPL2-2/BC (A)	NRR/DORL/LPL2-2/PM
NAME	JWachutka*(NLO)	TOrf	RSchaaf (JDion for)
DATE	7/19/2016	7/29/2016	7/29/2016

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