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

November 19, 2015

Mr. Bryan C. Hanson
Senior Vice President
Exelon Generation Company, LLC
President and Chief Nuclear Officer (CNO)
Exelon Nuclear
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: LASALLE COUNTY STATION, UNITS 1 AND 2, ISSUANCE OF AMENDMENT REVISING THE ULTIMATE HEAT SINK TEMPERATURE LIMIT (CAC NOS. ME9076 AND ME9077)

Dear Mr. Hanson:

The U.S. Nuclear Regulatory Commission (NRC or the Commission) has issued the enclosed Amendment Nos. 218 and 204 to Facility Operating License Nos. NPF-11 and NPF-18 for the LaSalle County Station (LSCS), Units 1 and 2, respectively. The amendments are in response to your application dated July 12, 2012, as supplemented by letters dated September 17, 2012, January 18, 2013, February 11, 2013, October 4, 2013, December 4, 2014, and April 15, 2015.

The amendments add a condition to Technical Specification 3.7.3, requiring performance of Surveillance Requirement (SR) 3.7.3.1 once per hour if Core Standby Cooling System Pond temperature is ≥101°F, and also modifies the temperature limit specified in SR 3.7.3.1 from "≤101.25 °F" to "within the limits of Figure 3.7.3-1." Figure 3.7.3-1, newly added by these amendments, provides diurnal temperature limits based on the time of day but that are no higher than 104 °F.

A copy of the related Safety Evaluation (SE) is also enclosed. The Notice of Issuance will be included in the Commission's biweekly *Federal Register* notice.

Your letters dated October 4, 2013, and December 4, 2014, and April 15, 2015, contained proprietary information. The NRC staff believes that the enclosed SE does not contain proprietary information. Nevertheless, the NRC staff will withhold public disclosure of this entire amendment package for 14 days from the date of issuance to allow you time to review the package. Please inform me within this period if you have any concerns regarding proprietary information.

Sincerely,

BKVaidya

Bhalchandra Vaidya, Project Manager
Plant Licensing III-2 and
Planning and Analysis Branch
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-373 and 50-374

Enclosures:
1. Amendment No. 218 to NPF-11
2. Amendment No. 204 to NPF-18
3. Safety Evaluation

cc w/encls: Distribution via ListServ

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

EXELON GENERATION COMPANY, LLC

DOCKET NO. 50-373

LASALLE COUNTY STATION, UNIT 1

AMENDMENT TO FACILITY OPERATING LICENSE

Amendment No. 218
License No. NPF-11

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

    A. The application for amendment to the LaSalle County Station, Unit 1 (the facility) Operating License No. NPF-11 filed by the Exelon Generation Company, LLC (the licensee) dated July 12, 2012, as supplemented by letters dated September 17, 2012, January 18, 2013, February 11, 2013, October 4, 2013, December 4, 2014, and April 15, 2015, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's regulations set forth in 10 CFR Chapter I;

    B. The facility will operate in conformity with the application, the provisions of the Act, and the 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 set forth in 10 CFR Chapter I;

    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 Technical Specifications as indicated in the attachment to this license amendment and paragraph 2.C.(2) of the Facility Operating License No. NPF-11 is hereby amended to read as follows:

(2) Technical Specifications and Environmental Protection Plan

The Technical Specifications contained in Appendix A, as revised through Amendment No. 218, and the Environmental Protection Plan contained in Appendix B, are hereby incorporated in the license. The licensee shall operate the facility in accordance with the Technical Specifications and the Environmental Protection Plan.

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

FOR THE NUCLEAR REGULATORY COMMISSION

Travis L. Tate, Chief
Plant Licensing III-2 and
Planning and Analysis Branch
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Attachment:
Changes to the Technical
Specifications and Facility Operating License

Date of Issuance: November 19, 2015

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

EXELON GENERATION COMPANY, LLC

DOCKET NO. 50-374

LASALLE COUNTY STATION, UNIT 2

AMENDMENT TO FACILITY OPERATING LICENSE

Amendment No. 204
License No. NPF-18

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

   A. The application for amendment to the LaSalle County Station, Unit 2 (the facility) Operating License No. NPF-18 filed by the Exelon Generation Company, LLC (the licensee) dated July 12, 2012, as supplemented by letters dated September 17, 2012, January 18, 2013, February 11, 2013, October 4, 2013, December 4, 2014, and April 15, 2015, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's regulations set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, the provisions of the Act, and the 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 set forth in 10 CFR Chapter I;

   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 Technical Specifications as indicated in the attachment to this license amendment and paragraph 2.C.(2) of the Facility Operating License No. NPF-18 is hereby amended to read as follows:

(2) Technical Specifications and Environmental Protection Plan

The Technical Specifications contained in Appendix A, as revised through Amendment No. 204, and the Environmental Protection Plan contained in Appendix B, are hereby incorporated in the license. The licensee shall operate the facility in accordance with the Technical Specifications and the Environmental Protection Plan.

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

FOR THE NUCLEAR REGULATORY COMMISSION

Travis L. Tate

Travis L. Tate, Chief
Plant Licensing III-2 and
Planning and Analysis Branch
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Attachment:
Changes to the Technical
Specifications and Facility Operating License

Date of Issuance: November 19, 2015

ATTACHMENT TO LICENSE AMENDMENT NOS. 218 AND 204

FACILITY OPERATING LICENSE NOS. NPF-11 AND NPF-18

DOCKET NOS. 50-373 AND 50-374

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

Remove	Insert
License	License
NPF-11, Page 3	NPF-11, Page 3
NPF-18, Page 3	NPF-18, Page 3
TSs	TSs
3.7.3-1	3.7.3-1
3.7.3-2	3.7.3-2
--	3.7.3-3

Am. 146 01/12/01 (4) Exelon Generation Company, LLC, 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 or instrument calibration or associated with radioactive apparatus or components; and

Am. 202 07/21/11 (5) Exelon Generation Company, LLC, 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 LaSalle County Station, Units 1 and 2 and such Class B and Class C low-level radioactive waste as may be produced by the operation of Braidwood Station, Units 1 and 2, Byron Station, Units 1 and 2, and Clinton Power Station, Unit 1.

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 thereafter in effect; and is subject to the additional conditions specified or incorporated below:

Am. 198 09/16/10 (1) <u>Maximum Power Level</u>

The licensee is authorized to operate the facility at reactor core power levels not in excess of full power (3546 megawatts thermal).

Am. 218 11/19/15 (2) <u>Technical Specifications and Environmental Protection Plan</u>

The Technical Specifications contained in Appendix A, as revised through Amendment No. 218, and the Environmental Protection Plan contained in Appendix B, are hereby incorporated in the license. The licensee shall operate the facility in accordance with the Technical Specifications and the Environmental Protection Plan.

Am. 194 08/28/09 (3) DELETED

Am. 194 08/28/09 (4) DELETED

Am. 194 08/28/09 (5) DELETED

Am. 194 08/28/09 (6) DELETED

Am. 194 08/28/09 (7) DELETED

Am. 189 07/21/11 (5) Pursuant to the Act and 10 CFR Parts 30, 40, and 70 possess, but not separate, such byproduct and special nuclear materials as may be produced by the operation of LaSalle County Station, Units 1 and 2, and such Class B and Class C low-level radioactive waste as may be produced by the operation of Braidwood Station, Units 1 and 2, Byron Station, Units 1 and 2, and Clinton Power Station, Unit 1.

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:

Am. 185 09/16/10 (1) Maximum Power Level

The licensee is authorized to operate the facility at reactor core power levels not in excess of full power (3546 megawatts thermal). Items in Attachment 1 shall be completed as specified. Attachment 1 is hereby incorporated into this license.

Am. 204 11/19/15 (2) Technical Specification and Environment Protection Plan

The Technical Specifications contained in Appendix A, as revised through Amendment No. 204, and the Environmental Protection Plan contained in Appendix B, are hereby incorporated in the license. The licensee shall operate the facility in accordance with the Technical Specifications and the Environmental Protection Plan.

Am. 181 08/28/09 (3) DELETED

Am. 181 08/28/09 (4) DELETED

Am. 181 08/28/09 (5) DELETED

Am. 181 08/28/09 (6) DELETED

Am. 181 08/28/09 (7) DELETED

Am. 181 08/28/09 (8) DELETED

Am. 181 08/28/09 (9) DELETED

3.7 PLANT SYSTEMS

3.7.3 Ultimate Heat Sink (UHS)

LCO 3.7.3 The Core Standby Cooling System (CSCS) pond shall be OPERABLE.

APPLICABILITY: MODES 1, 2, and 3.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. CSCS pond inoperable due to sediment deposition or bottom elevation not within limit.	A.1 Restore CSCS pond to OPERABLE status.	90 days
B. Cooling water temperature supplied to the plant from the CSCS pond ≥ 101°F.	B.1 Perform SR 3.7.3.1.	Once per hour
C. Required Action and associated Completion Time of Condition A not met. <u>OR</u> CSCS pond inoperable for reasons other than Condition A.	C.1 Be in MODE 3. <u>AND</u> C.2 Be in MODE 4.	12 hours 36 hours

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.7.3.1	Verify cooling water temperature supplied to the plant from the CSCS pond is within the limits of Figure 3.7.3-1.	In accordance with the Surveillance Frequency Control Program
SR 3.7.3.2	Verify sediment level is ≤ 1.5 ft in the intake flume and the CSCS pond.	In accordance with the Surveillance Frequency Control Program
SR 3.7.3.3	Verify CSCS pond bottom elevation is ≤ 686.5 ft.	In accordance with the Surveillance Frequency Control Program

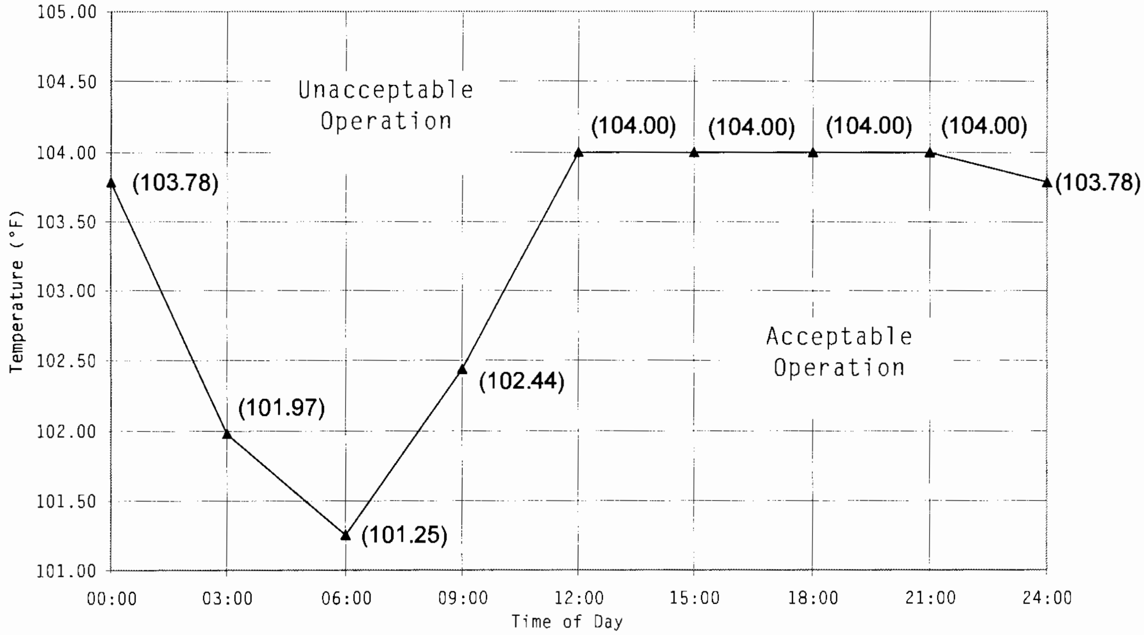

Figure 3.7.3-1 (page 1 of 1)
Temperature of Cooling Water Supplied to the Plant from the CSCS Pond Versus Time of Day Requirements

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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 218 TO FACILITY OPERATING LICENSE NO. NPF-11

AND AMENDMENT NO. 204 TO FACILITY OPERATING LICENSE NO. NPF-18

EXELON GENERATION COMPANY, LLC

LASALLE COUNTY STATION, UNITS 1 AND 2

DOCKET NOS. 50-373 AND 50-374

1.0 INTRODUCTION

By application dated July 12, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12200A330), as supplemented by letters dated September 17, 2012 (ADAMS Accession No. ML122690041), January 18, 2013 (ADAMS Accession No. ML13022A476), February 11, 2013 (ADAMS Accession No. ML13042A405), October 4, 2013 (ADAMS Accession No. ML13282A339), December 4, 2014 (ADAMS Accession No. ML14352A319), and April 15, 2015 (ADAMS Accession No. ML15113B115), Exelon Generation Company, LLC (EGC, the licensee) requested changes to the Technical Specifications (TSs) for the LaSalle County Station (LSCS), Units 1 and 2.

The supplemental letters dated December 4, 2014, and April 15, 2015, provided additional information that clarified the application, but did not expand the scope of the application as originally noticed, and did not change the U.S. Nuclear Regulatory Commission (NRC or the Commission) staff's original proposed no significant hazards consideration determination as published in the *Federal Register* on August 5, 2014 (79 FR 45489).

Currently, Surveillance Requirement (SR) 3.7.3.1 requires verification of the cooling water temperature supplied to the plant from the ultimate heat sink (UHS) to be ≤101.25 °F. If the UHS indicated temperature exceeds 101.25 °F, Section 3.7.3, Required Actions B.1 and B.2, would be entered concurrently, requiring both units to be placed in Mode 3 within 12 hours and Mode 4 within 36 hours.

The licensee stated that the proposed amendment is needed because recent summer meteorological conditions, which include elevated air temperatures, high humidity, and low wind speed, have challenged the UHS current temperature limit of 101.25 °F. Since the diurnal effect of the weather conditions heats up the UHS during the day and cools off the UHS during the night, the proposed amendment would allow the technical specification (TS) temperature limit of the cooling water supplied to the plant from the UHS to vary with the diurnal cycle, but not to exceed 104 °F.

The license also proposed to add a CONDITION to TS 3.7.3, requiring performance of SR 3.7.3.1 once per hour if the core standby cooling system (CSCS) pond temperature is ≥101 °F. The licensee further proposed to modify the temperature limit specified in SR 3.7.3.1 from the current "≤101.25 °F" to "within the limits of Figure 3.7.3-1." The proposed Figure 3.7.3-1 provides diurnal temperature limits based on time of day.

2.0 REGULATORY EVALUATION

The NRC staff reviewed the licensee's application, as supplemented, against the following regulatory requirements and regulatory guidance documents.

2.1 Regulatory Requirements

Title 10 of the *Code of Federal Regulations* (10 CFR), Paragraph 50.36(c)(2), states that limiting conditions for operation (LCOs) are the lowest functional capability or performance level of equipment required for safe operation of the facility, and when LCOs are not met, the licensee shall shut down the reactor or follow any remedial action permitted by the TSs until the LCO can be met.

Paragraph 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 50.120 of 10 CFR, "Training and Qualification of Nuclear Power Plant Personnel," requires that the training program must incorporate the instructional requirements necessary to provide qualified personnel to operate and maintain the facility in a safe manner in all modes of operation. The training program must be developed to be in compliance with the facility license, including all TSs and applicable regulations.

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.

> GDC 5, "Sharing of Structures, Systems, and Components," requires that SSCs important to safety shall not be shared among nuclear power units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions, including, in the event of an accident in one unit, an orderly shutdown and cool down of the remaining units.
>
> GDC 13, "Instrumentation and Control," requires that instrumentation shall be provided to monitor variables and systems over their anticipated ranges for normal operation, for anticipated operational occurrences, and for accident conditions as appropriate to assure adequate safety, including those variables and systems that can affect the fission

process, the integrity of the reactor core, the reactor coolant pressure boundary, and the containment and its associated systems. Appropriate controls shall be provided to maintain these variables and systems within prescribed operating ranges.

GDC 16, "Containment Design," requires reactor containment and associated systems shall be provided to establish an essentially, leak-tight barrier against the uncontrolled release of radioactivity to the environment and to assure that the containment design conditions important to safety are not exceeded for as long as postulated accident conditions require.

GDC 38, "Containment Heat Removal," requires a containment heat removal system safety function which should reduce rapidly, consistent with the functioning of other associated systems, the containment pressure and temperature following any loss-of-coolant accident (LOCA) and to maintain them at acceptably low levels.

GDC 41, "Containment Atmosphere Cleanup," requires a standby gas treatment system which should reduce, consistent with the functioning of other associated systems, the concentration and quality of fission products released to the environment following postulated accidents.

GDC 44, "Cooling Water," requires that a system to transfer heat from structures, systems, and components (SSCs) important to safety, to a UHS shall be provided. The system safety function shall be to transfer the combined heat load of these SSCs under normal operating and accident conditions. Suitable redundancy in components and features, and suitable interconnections, leak detection, and isolation capabilities shall be provided to assure that for onsite electric power system operation (assuming offsite power is not available) and for offsite electric power system operation (assuming onsite power is not available) the system safety function can be accomplished, assuming a single failure.

GDC 50, "Containment Design Basis," requires the containment heat removal system shall be designed so that the containment structure and its internal compartments can accommodate without exceeding the design leakage rate and with sufficient margin, the calculated pressure and temperature conditions resulting from any LOCA.

2.2 Guidance Documents

NUREG-0800, "Standard Review Plan (SRP) for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR (Light Water Reactor) Edition." Section 9.2.5, "Ultimate Heat Sink," Revision 3, dated March 2007 (ADAMS Accession No. ML070550048), provides guidance for evaluating UHSs.

NUREG-0800, "Standard Review Plan (SRP) for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR (Light Water Reactor) Edition." Chapter 18, "Human Factors Engineering," Revision 2, March 2007 (ADAMS Accession No. ML070670253).

NUREG-1764, "Guidance for the Review of Changes to Human Actions" (ADAMS Accession No. ML072640413). The licensee's application was determined to be a non-risk-informed submittal. Therefore, in accordance with the generic risk categories established in Appendix A to NUREG-1764, using Table A.1, "Generic BWR [boiling-water reactor] Human Actions That Are Risk-Important," the NRC staff determined that the appropriate level of human factors review was determined to require a Level II effort.

Regulatory Guide (RG) 1.27, "Ultimate Heat Sink for Nuclear Power Plants," Revision 2, dated January 1976 (ADAMS Accession No. ML003739969), describes a basis acceptable to the NRC staff that may be used to implement GDC 44. The RG states that a UHS serving multiple units should be capable of providing sufficient cooling water to permit simultaneous safe shutdown and cool down of all units it serves and to maintain them in a safe shutdown condition. The RG also states that in the event of an accident in one unit, the UHS should be able to dissipate the heat for that accident safely, to permit the concurrent safe shutdown and cool down of the remaining unit, and to maintain all units in a safe shutdown condition.

Section 9.2.6.1.1 of the LSCS updated final safety analysis report (UFSAR) (ADAMS Accession No. ML14113A093) states that the UHS has the following design bases:

a) To provide sufficient water volume permitting a safe shutdown and cool down of the station for 30 days with no water makeup for both normal operating and accident conditions - the initial maximum water temperature supplied to the plant is taken as 101.25 °F. The UHS post-accident temperature analysis indicates a peak water supply temperature of 104 °F,
b) To withstand the most severe postulated natural phenomenon as discussed in Chapter 2.0,
c) To withstand the postulated site-related incidents as discussed in Subsection 2.5.5, and
d) To provide water for fire protection equipment.

Revision 1 of RG 1.105, "Instrument Setpoints" (ADAMS Accession No. ML13064A112), describes a method acceptable to the NRC staff for complying with the NRC's regulations for ensuring that instrumentation setpoints are initially within and remain within the TS limits.

3.0 TECHNICAL EVALUATION

3.1 Description of the UHS and Proposed TS Change

According to the LSCS UFSAR, the UHS is designed to meet the requirements of GDC 44. The UHS is an excavated pond located below and integral with the cooling lake. The UHS has a bottom elevation of approximately 685 feet and a top elevation at 690 feet. The cooling lake covers and extends beyond the UHS with a top elevation of approximately 700 feet. In the unlikely event that the main dike of the cooling lake fails, the UHS remains intact and is designed to hold 460 acre-feet of water with a surface area of 83 acres. The UHS provides sufficient cooling water to permit the safe shutdown and cool down of both units for 30 days with no makeup for both normal and accident conditions. The current maximum allowed temperature for water supplied from the UHS to the plant is 101.25 °F, which includes instrument uncertainty. The UHS temperature would peak at 104 °F under accident conditions and worst-weather conditions. The UHS is designed to withstand the most severe postulated natural phenomenon. A seismic event could cause the loss of the large cooling lake, but the submerged UHS pond would remain intact. Under accident conditions, the UHS supplies the

CSCS equipment to include eight residual heat removal (RHR) service water pumps, three diesel generator (DG) cooling water pumps and two high pressure core spray DG pumps. The UHS would also supply fire protection water and could supply emergency makeup water for the spent fuel pools. The function of the UHS is to provide cooling of the RHR heat exchangers, DG coolers, emergency core cooling system cubicle area cooling coils, RHR pump seal coolers, and low pressure core spray pump motor cooling coils.

The CSCS is the safety-related service water system that draws from the UHS. During a design basis accident (DBA), the CSCS supplies cooling water to equipment needed to mitigate a DBA in one unit and provide cooling water for safe shutdown and cooldown of the non-accident unit. The CSCS draws cooling water from one end of the UHS, performs its design function in the plant and then discharges to the other end of the UHS. The heated discharge water then migrates or flows to the end of the UHS where the CSCS takes suction. While flowing from the discharge end to the suction end of the UHS, the water absorbs heat energy from the sun and atmosphere and loses heat energy due to evaporation, conduction, convection and back radiation from the pond surface. The licensee has used the methodology set forth in NUREG-0693, "Analysis of Ultimate Heat Sink Cooling Ponds" (ADAMS Accession No. ML12146A144), to calculate the heat transfer taking place in the UHS after a DBA.

In this amendment request, the licensee proposes to revise the TS to allow the maximum UHS supply temperature, when in Modes 1-3, to be dependent on the time of day (diurnally dependent) such that the peak post-accident water supply temperature, based on analysis of the worst combination of pre-accident and post-accident conditions, will not exceed 107 °F. Specifically, the licensee proposes a revision to TS 3.7.3 by adding new Condition B, which would state "CONDITION: Cooling water temperature supplied to the plant from the CSCS pond ≥101 °F, REQUIRED ACTION: Perform SR 3.7.3.1., COMPLETION TIME: Once per hour."

SURVEILLANCE REQUIREMENT 3.7.3.1 currently reads, "Verify cooling water temperature supplied to the plant from the CSCS pond is ≤101.25 °F." The licensee proposes changing SR 3.7.3.1 to read, "Verify cooling water temperature supplied to the plant from the CSCS pond is within the limits of Figure 3.7.3-1." Proposed Figure 3.7.3-1 is provided below.

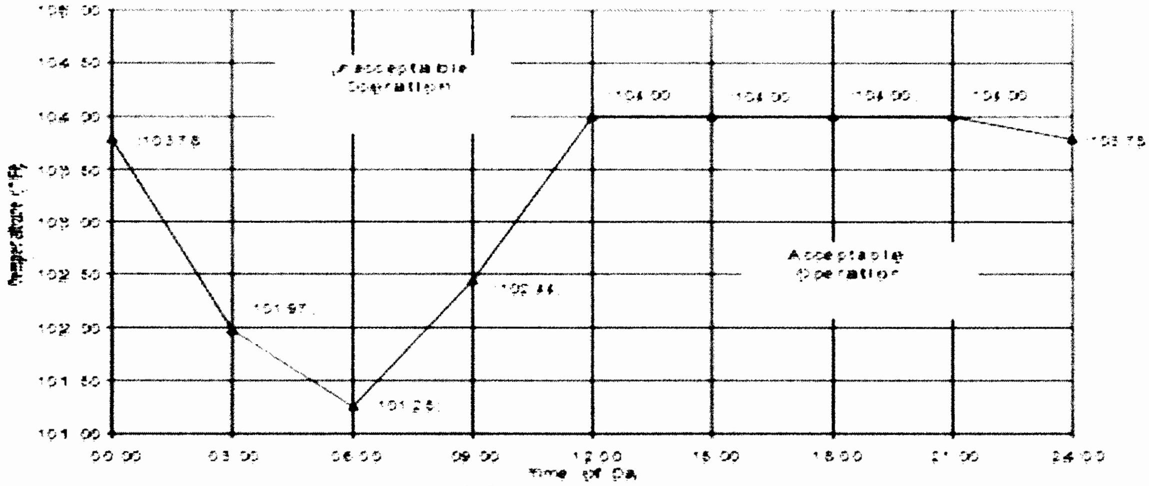

Figure 3.7.3-1 (page 1 of 1)
Temperature of Cooling Water Supplied to the Plant from the CSCS Pond Versus Time of Day Requirements

3.2 Calculation of Maximum UHS Temperature

The main objective of this NRC staff safety evaluation (SE) is to ensure that the UHS with the CSCS continues to meet the regulatory requirements of GDC 5 and GDC 44. The NRC staff considers that the requirements of GDC 5 and GDC 44 are met for the UHS if the license amendment request (LAR) adheres to the guidelines of RG 1.27 and the licensing basis stated in the UFSAR. The UHS will meet the regulatory requirements and guidelines if it provides sufficient cooling water to permit safe shutdown and cool down of the station for 30 days with no makeup for both normal and accident conditions.

The current TS and licensing basis are based on an allowed peak UHS return temperature of 104 °F during a design basis accident. For the proposed TS changes, the licensee used 107 °F as an upper temperature limit for UHS peak return temperature. The UHS peak return temperature limit of 107 °F was based on the data provided in Table A5-1 of the application dated July 12, 2012, which specified design fouling factors and tube plugging allowances that allowed very small margins for heat exchangers cooled by CSCS, (i.e., 1.5 percent and 1.7 percent margin for emergency diesel generators (EDGs) coolers and <1 percent margin for RHR heat exchangers). The licensee stated that the heat transfer capabilities and fouling factors are verified on a regular basis in accordance with Generic Letter (GL) 89-13, "Service Water System Problems Affecting Safety-Related Equipment."

The NRC staff was not reasonably assured that the licensee's GL 89-13 testing verified heat transfer capability with sufficient accuracy and margin to account for the small thermal margins associated with 107 °F cooling water temperature. Therefore, in a request for additional information (RAI) dated January 9, 2013, the NRC staff asked the licensee to justify reliance on GL 89-13 testing as a means of assuring that the required heat transfer capability of the RHR and DG coolers are maintained. The licensee responded in a letter dated January 18, 2013, stating that itperforms GL 89-13 testing in accordance with the LSCS GL 89-13. The licensee stated that for GL 89-13 heat exchanger testing, multiple precision resistance temperature detectors are evenly spaced around the circumference of the test piping. The test data is averaged and input into software that uses a benchmarked heat exchanger model. The software is able to compute the fouling factor and heat transfer capability of the heat exchanger at design conditions. Instrument uncertainty is taken into account to determine the uncertainty in the test results. The most recent GL 89-13 tests of the DG jacket water coolers show approximately 37-78 percent thermal margins at design conditions. The most recent GL 89-13 test of the RHR heat exchangers show approximately 10-19 percent thermal margin at design conditions. The NRC staff notes that the as tested thermal margins are larger than the design thermal margins because the computed thermal capability of the heat exchangers are greater than the design capability. This is caused by the actual number of tubes plugged being significantly less than the tube plugging allowance and the computed fouling factors being significantly smaller than the design fouling factors. Since future GL 89-13 testing may show the thermal capability of the heat exchangers decreasing toward the design thermal margins, which are the minimal acceptance criteria, the NRC staff engaged the licensee in the tele-conference on November 4, 2015. The licensee informed the NRC staff that the performance of the heat exchangers in the CSCS is monitored and trended by the GL 89-13 program manager through thermal performance testing. If the available operating margin approaches the design margin stated in design basis analyses, the issue will be entered into the margin management program defined by procedure ER-AA-2007, "Management of Design and Operating Margins." This program tracks low design and operating margin components at the station. The items are presented to station management on a regular basis to determine actions for maintaining or improving the available design and operating margin. Based on the licensee's testing and monitoring of the thermal capability of the heat exchangers serviced by CSCS and the UHS in accordance with the GL 89-13 testing and cleaning program and the margin management program provided by procedure ER-AA-2007, the NRC staff finds acceptable the use of 107 °F as the peak UHS return temperature for equipment cooled by the UHS.

The UHS provides a heat sink for equipment important to safety for a minimum of 30 days without makeup. LSCS's UHS recycles its water and relies on evaporation, conduction and convection to the environment for heat removal of the energy added to the UHS from the plant and solar heating during a DBA LOCA event. Transient analysis is necessary to determine peak UHS return temperature. The licensee performed its transient analysis using the plug flow methodology described in NUREG-0693. The licensee applied the heat transfer relationships and associated equations of NUREG-0693 to calculate the temperature and water inventory transients of the UHS during the DBA LOCA. The heat transfer relationships use various design/calculation inputs, including wind direction and speed, dry bulb temperature, dew point temperature, solar and atmospheric radiation, atmospheric pressure, fraction of sky covered by clouds, water surface temperature, saturated vapor pressure, partial vapor pressure, and relative humidity. The design/calculation inputs are taken from the most severe historical weather data that are applicable to the site. The intent in selecting the worst historical weather data is twofold. First, the weather data is selected to yield the highest CSCS inlet temperature (peak UHS return temperature) after a DBA LOCA in order to ensure the peak return temperature would not exceed the maximum allowed cooling water temperature to any of the components to be cooled by the CSCS. Second, the worst-weather data are selected to cause the maximum evaporation losses over the 30-day period, and thus, result in the minimum volume of water available for cooling the UHS during the DBA LOCA.

The licensee has modeled the closed loop cooling system as a plug flow model, called LAKET-PC, as described in NUREG-0693 to simulate the UHS flow. According to the licensee:

> The computer program used to model the LaSalle [LSCS] UHS during the design event is...a one-dimensional thermal prediction model for bodies of water. The model assumes that the temperature is constant at any point along the plane perpendicular to the direction of the flow. The one dimensional model assumptions coerce the water body into an idealized rectangular channel. The movement of fluid through the one-dimensional channel is envisioned as a series of individual, distinct fluid segments. Each segment has an individual length and temperature, while the width and depth remain constant for all. The channel thus forms a queue of fluid segments, where additions are made at the inlet, and deletions are made at the outlet. Any segment that enters the channel will cause an equal amount to be expelled at the outlet. The program assumes that all segments are uniform in temperature, and each segment is allowed to react independently with the environment. The horizontal heat conduction for each segment is assumed to be negligible with respect to the heat rejection at the air-water interface and is ignored. Similarly, conductive heat loss at the water channel interface is ignored.

The licensee's one-dimensional model assumes no thermal stratification since the model depends on the temperature being constant at any point along the plane perpendicular to the direction of the flow. The plug flow model uses UHS volume and surface area. Since the UHS pond contains stagnant areas which are not part of the UHS flow path, the licensee performed computational fluid dynamics (CFD) analysis to determine the effective volume and surface area of the cooling water flow in the UHS. By CFD, the licensee determined that the effective volume and surface area is 63.4 percent and 57.9 percent of the UHS, respectively. As part of its review, the NRC staff had a confirmatory analysis performed. A copy of the confirmatory analysis technical evaluation report is available at ADAMS Accession No. ML15195A055 and is discussed in SE Section 3.2.1. Part of the confirmatory analysis included the sensitivity analysis that implemented a 2-foot stratified layer rather than a homogeneous plug flow. The stratified sensitivity analysis showed a decrease in peak UHS temperature since the hotter surface water more readily transferred heat to the environment. Therefore, the licensee's assumption of no stratification is conservative. The confirmatory analysis also performed a sensitivity analysis regarding the reduction in surface area and volume as a means of checking the influence and accuracy of the CFD analysis. Neither a 10% nor a 25% reduction in surface area and volume had any adverse effect on peak UHS temperature when using the more accurate Ryan wind function.

The methodology used in the plug model is consistent with the thermal model presented in NUREG-0693, "Analysis of Ultimate Heat Sink Cooling Ponds" (ADAMS Accession No. ML12146A144), and the wind speed functions presented in Massachusetts Institute of Technology (MIT) Report No. 161, "An Analytical and Experimental Study of Transient Cooling Ponds Behavior," dated January 1973, which is also referenced and cited in NUREG-0693. Consistent with NUREG-0693, the plug flow contributing components for the net heat transfer, Q, to the UHS are:

$$Q = Q_{SN} + Q_{AN} - Q_{BR} - Q_E - Q_C + Q_{RJ}$$

Where:

Q = net heat transfer to the UHS
Q_{SN} = net incident short wave solar radiation
Q_{AN} = net incident long wave atmospheric radiation
Q_{BR} = net rate of long wave back radiation from the lake surface
Q_E = net rate of heat loss due to evaporation
Q_C = net rate of heat loss due to conduction and convection
Q_{RJ} = net rate of heat rejected to the lake by the plant

Other than heat rejected from the plant, the contributing components of heat transfer to/from the UHS are functions of the ambient weather conditions. Per RG 1.27, the licensee must consider the worst-weather conditions as determined by the previous 30 years of weather data. The licensee must consider two weather periods, i.e., the period that results in the highest peak temperature of cooling water inlet to the plant and the worst 30 days of weather that result in maximum evaporation to ensure that the UHS will perform its safety function for a minimum of 30 days.

The current TS and licensing basis are based on the worst-weather periods taken from the historical weather data from the weather stations at nearby cities in Peoria and Springfield, Illinois, for the dates from July 4, 1948, through June 30, 1996. The licensee's application for the proposed amendment added additional meteorological data from the LSCS site and Peoria from January 1, 1995, through September 30, 2010. Wind speed, wind direction, and dry-bulb temperature data were taken from an on-site meteorological tower at LSCS. Humidity, precipitation type, cloud height, and cloud cover data were not available from the on-site meteorological tower, and were thus taken from a National Weather Service observing station at the Peoria airport (approximately 70 miles southwest of LSCS). The licensee determined the worst-weather periods by creating a specific open cycle UHS model in the LAKET-PC computer program with a transit time of three hours. The UHS temperature or evaporation amount for each 3-hour period corresponds to the environmental effects on the UHS during those three hours. Each 3-hour period during the entire historical weather period was evaluated independently for only that period's effect on temperature rise and evaporation. Rolling average temperature effects for 24 hours and 30 days and other time intervals were developed by the licensee from the independent 3-hour UHS model to find the worst-weather periods for those time intervals during the entire historical weather period. The same rolling average methodology was used to find the consecutive 30 days in the historical weather data that yielded the most evaporation. The 24-hour and 30 day time spans and other time spans were combined in synthetic weather periods and used as design input for the UHS plug flow model. Using peak plant cooling water inlet temperature as the criteria for selecting worst-weather periods and varying the start of the weather period based on time of day (i.e., 12 a.m., 3:00 a.m., 6:00 a.m., 9:00 a.m., 12:00 p.m., 3:00 p.m., 6:00 p.m., and 9:00 p.m.), the licensee initially determined worst-weather periods for 24 hours and 30 days which are:

1-day:	July 24, 2001, 6:00 a.m. to July 25, 2001, 6:00 a.m.
30 days:	July 21, 1995, 3:00 p.m. to August 20, 1995, 3:00 p.m.

The worst 30-day evaporation weather period remains June 18, 1954, to July 18, 1954, as before. The licensee combined the meteorological data from the worst-weather periods for design input into the one-dimensional thermal prediction model for the UHS (i.e., LAKET-PC) and developed the proposed TS limits. All analyses assume that the cooling lake dike fails instantaneously and concurrently with the DBA LOCA. Therefore, only the UHS pond as represented by the plug flow model is assumed to be available to mitigate the accident.

The licensee's plug flow model determined the transit time for flow across the UHS pond during a DBA LOCA to be 30 hours, using the effective volume and surface area from the CFD analysis, a UHS sediment level of 1.5 feet and an 86 ft^3/second flow rate with all CSCS pumps running. In the DBA LOCA analysis, the licensee initially considered the worst 24 hour period of meteorological conditions for controlling parameters followed by the worst 30 days for evaporation. The worst intervals of time of meteorological data were computed by a highest averaging method as described above. By considering the worst 24-hour period as the initial time period, the licensee's plug flow analysis showed that the peak temperature of the UHS after a LOCA initiated at the worst time (6:00 a.m.) would be approximately 9 hours after the LOCA, which occurs 21 hours before any of the UHS water that is affected by accident heat input reenters the plant intake. The licensee's analysis shows that the UHS inlet temperature from the plant or plant discharge to be above 120 °F for most of the first day after the DBA LOCA, yet the UHS outlet to the plant or plant inlet has already peaked at 107 °F at about 3:00 p.m. the first day. According to Figure 4 of the July 12, 2012, application, the maximum temperature of the UHS outlet temperature on the second day is below the maximum temperature on the first day, indicating that the heat added by the DBA-LOCA has little effect on the UHS outlet temperature.

The NRC staff questioned whether the seeming lack of influence upon peak UHS temperature by the accident heat could be attributed to a relatively cool, cloudy or windy day after the first day following the DBA LOCA, which is the first day of the 30 day evaporation period. The NRC staff's confirmatory analysis, though, found that the absence of accident heat as a determining factor of peak UHS temperature was attributed to a large heat sink that dissipates the accident heat before the affected water reaches plant intake. However, heat waves where weather extremes have persisted for multiple consecutive days have occurred in the area. Thus, considering a heat wave in progress and a first critical time period of 24 hours as used by the licensee, the first day of the worst 30-day period may not be representative of the actual second day of a heat wave after a DBA-LOCA. Therefore, the NRC staff asked in an RAI dated January 9, 2013 (ADAMS Accession No. ML12320A422) that the licensee justify its selection of weather data and critical time periods or propose a new analysis that would address the NRC staff's concerns.

In its February 11, 2013, letter, the licensee stated that it had used a highest averaging approach to obtain the worst 774-hour consecutive hours of weather data to perform a sensitivity analysis which determined that there was an additional 3.5 °F of margin as compared to the proposed TS limit. The NRC staff questioned the licensee's approach of selecting the worst weather data by computing the highest average temperature effect of a 774 consecutive hour time span within the historical weather time period. Although it may be possible to use a 774 consecutive hours of data approach in conformance with the then current revision to RG 1.27, this averaging approach of finding the worst 774 hours does not necessarily capture the limiting data for the first critical time period of the transit time when UHS temperature to safety-related components is expected to peak. As stated in RG 1.27, Revision 2, "sufficient conservatism should be provided to ensure that a 30-day cooling supply is available and that design basis temperatures of safety related equipment are not exceeded," and "[t]he meteorological conditions resulting in minimum water cooling should be the worst combination of controlling parameters, including diurnal variations where appropriate, for the critical time periods unique to the specific design of the sink." Selecting meteorological data from a 774-hour period based on the highest running UHS temperature may not include the worst first few days when peak UHS input to the plant is expected at LSCS.

In addition, the licensee stated that it had performed additional weather screenings for the worst meteorological conditions for 33, 36 and 39-hour transit times which correspond to varying levels of sedimentation in the pond. The licensee also performed additional weather screening for accident start times at each 3-hour increment for a 24-hour period. These additional screenings demonstrated that the June 22, 2009, to June 23, 2009, period was the limiting period for all considered accident starting times and transit times. The licensee then performed sensitivity evaluations for a DBA LOCA occurring on June 22, 2009, using the 774 consecutive hour approach starting with the worst 30 hours on June 22, 2009. The licensee performed this sensitivity analysis with some conservatisms removed. For example the licensee used a residual heat release from the accident and non-accident reactors and associated systems and components to more closely match actual conditions where accident heat is first transferred to the suppression pool before transfer to the UHS. Additionally, the licensee removed the Lake Hefner wind function which adds margin to the analysis. The peak UHS temperature occurred on the second day approximately 32 hours after the DBA-LOCA initiation at 6:00 a.m. and showed that the 107 °F design limit would not be exceeded. The calculated margin varied from 1.61 °F to 2.47 °F, depending on the time of day of the design basis event's occurrence and with 18 inch sedimentation. It was unclear to the NRC staff whether limiting environmental conditions were applied as part of the licensee's response to the RAI. Therefore, in an RAI dated June 27, 2013 (ADAMS Accession No. ML13099A206), the NRC staff asked the licensee to provide UHS modeling and analysis based on limiting environmental data and 30-day water supply in the UHS, to determine the peak UHS temperature to safety-related equipment. In its letter dated October 4, 2013, the licensee responded with an analysis as documented in Attachment O of UHS calculation L-002457. The licensee performed multiple runs of UHS analyses using the worst weather periods corresponding to transit times of 45 hours, 42 hours, 39 hours, 33 hours plus the next 30 days at 3 hour intervals in a day and found that the peak UHS temperature for all runs was 106.15 °F which is less than the 107 °F design temperature limit.

Using the regulatory guidance of RG 1.27, the licensee also ran LAKET-PC case runs using the worst weather time period consisting of the first critical time period with a combination of the worst 24 hours and the worst 30 days in a consecutive synthetic weather pattern. The most limiting critical time period would be that associated with the quickest recirculation time which would be associated with the highest allowed sedimentation level. Thus, the licensee determined the most limiting critical time period is 33 hours which is associated with 18 inches of sediment. The resultant synthetic weather period would be the worst 33 hours combined with the worst 24 hours and the worst 30 days. Recognizing 6:00 a.m. as the most limiting daily start time because of maximum solar effects, the licensee ran multiple LAKET-PC runs with the synthetic weather period for starting times of 6:00 a.m. and 9:00 a.m. using the worst 33 hours combined with the worst 24 hours and the worst 30 days. In each case, the peak plant cooling water inlet temperature did not exceed 107 °F when starting LAKET-PC case runs with the proposed TS limit as presented in the LAR.

The NRC staff identified a concern with whether the licensee accounted for maximum possible heat rejection to the UHS under all operating conditions within the design basis. The NRC staff's concern involved whether the analysis should include bounding cooling requirements for the spent fuel pool (SFP) and all available heat input, including both cooling trains of the RHR system, using any applicable operating and/or emergency procedure in a bounding DBA LOCA. The licensee's analysis did not use the Seismic Category II fuel pool cooling system but instead added makeup water from the UHS to the SFP as a means of removing decay heat from the SFP. The NRC staff also identified a concern with whether the licensee had also considered the fuel pool cooling assist mode of the RHR system in case that method is used for fuel pool cooling. In an RAI dated June 27, 2013 (ADAMS Accession No. ML13099A206), the NRC staff asked the licensee to provide heat load calculations to be relied on for TS limits, heat load for a fully loaded SFP, peak heat rejection rates under emergency and operating procedures and justification for variation in the peak heat load not affecting the proposed TS limits.

The licensee's October 4, 2013, supplement provided a revised UHS analysis based upon an operating scenario that maximizes heat load to the UHS considered all operating lineups allowed by procedure to maximize the heat input to the UHS and to consider the heat load from the SFP based on the maximum spent fuel elements allowed by TSs. The scenario considered a DBA LOCA at one unit and a reactor scram at the other unit. Both RHR heat exchangers are in operation for the DBA LOCA. For the non-LOCA unit, one RHR heat exchanger is placed into suppression pool cooling mode and later shutdown cooling mode while the other RHR heat exchanger is placed in fuel pool cooling assist mode after the spool piece hookup which takes about 16 hours. The licensee assumed the bounding heat loads for spent fuel pool loading allowed by TS and non-LOCA unit reactor core decay heat with the maximum allowed cool down rate of the non-LOCA unit, mitigating the LOCA in the accident unit using two trains of RHR, with one train of RHR for the non-LOCA unit in spent fuel cooling assist mode. The total plant flow during the UHS analysis is 29,300 gallons per minute (gpm) (65.3 ft^3/s) for the first 16 hours of the event. The total plant flow is 38,600 gpm (86.0 ft^3/s) after 16 hours. The licensee assumed that the reactors were operating at current licensed thermal power. This scenario represents the maximum heat load to the UHS. Therefore, the NRC staff found the licensee's response to be acceptable.

The NRC staff also had concerns regarding the plug flow model adequately accounting for mixing at the plant discharge. Specifically, the model segments closest to the plant discharge to the UHS experience significant turbulent flow and mixing due to the 38,600 gpm discharge. The turbulent flow would cause mixing with corresponding lower surface temperatures in the first few segments of the UHS model as compared to that in the model without mixing. Lower actual surface temperatures than that determined by the plug flow model would cause less evaporative heat transfer to the environment than predicted by the model. Thus, the NRC staff was concerned that the licensee's modeling of the effects of evaporative cooling driven by the temperature difference between the water surface and the surrounding air may be non-conservative. Therefore, in a June 27, 2013, RAI (ADAMS Accession No. ML13099A206), the NRC staff requested the licensee to provide detailed analysis using a UHS model that conservatively accounts for fluid segment mixing and corresponding lower surface water temperature.

The licensee responded in its supplement dated October 4, 2013, providing additional analysis documented in Attachment O of UHS calculation L-002457. The licensee stated that sensitivity runs were completed to show that mixing up to 20 percent has an insignificant impact on the peak plant cooling water inlet temperature and that the highest maximum UHS temperature occurs when no mixing zone is considered. The results of the analysis show that while mixing does indeed decrease the surface temperature of the segments, the lower starting surface temperature results in a lower ending surface temperature. The effect of mixing was also verified by the NRC staff's confirmatory analysis discussed below. The confirmatory analysis involved sensitivity analysis for the effects of entrance mixing in the licensee's model. The sensitivity analysis reduced the mixing volume of the first segment from 25 percent to 12.5 percent and showed little effect on peak plant inlet temperature using either the Ryan (Ryan, P.J. and D.R.F. Harleman, "An Analytical an Experimental Study of Transient Cooling Pond Behavior," Report No. 161, R.M. Parsons Laboratory for Water Resources and Hydrodynamics, Department of Civil Engineering, MIT, 1973) or Brady (Brady, D.K., W.L. Graves, and J.C. Geyer, "Surface Heat Exchange at Power Plant Cooling Lakes," Report No. 5, Publication 69-401, New York City, New York: Edison Electric Institute, 1969) wind function.

The NRC staff found the licensee's response acceptable in that the licensee determined that mixing at the plant discharge to the UHS does not adversely affect the peak UHS supply temperature for a DBA LOCA. The NRC staff was also concerned regarding the licensee's modeling of wind effects. The terrain around the UHS would affect the wind speed over the pond. Wind speed at the surface of the UHS pond contributes to the heat loss from the UHS pond from convection and evaporative cooling. The water surface of the UHS flume would be 10 to 20 feet below the surrounding embankment when the cooling lake above the UHS pond was lost during the DBA LOCA. The NRC staff was concerned that the licensee's modeling of wind speed over the surface of the UHS may be inaccurate or non-conservative because of the effects of the terrain. The licensee had used a wind speed ratio exponent of 0.3, which was based on a structural engineering book, "Wind Effects on Structures." The NRC staff, in a June 27, 2013, RAI (ADAMS Accession No. ML13099A206), requested the licensee to provide detailed analysis using a UHS model that conservatively accounts for surface wind speed. In its supplement dated October 4, 2013, the licensee addressed these concerns. The licensee performed a quantitative evaluation of the wind effect. A wind tunnel analysis was performed using a 1:500 scale model of the plant site and UHS elevation of 690 feet. The study conducted wind measurements at 22.5° increments to determine the limiting wind direction at the station. The study determined the ratios of the wind speed at the 114 m (375 ft) meteorological tower elevation, which corresponds to 123 meters (m) above the UHS surface, to the wind speed at 2 m (6.6 ft) over the UHS as a function of wind direction. The 2 m wind speed value is needed for accuracy in using the Ryan heat transfer formula. The overall average wind speed ratio is 0.573 which corresponds to a power law exponent of 0.135 and is less than 0.3 assumed by the licensee. The NRC staff finds that the licensee's wind speed ratio exponent is conservative with respect to the results of the wind tunnel analysis. The wind study does not account for the temperature difference between the UHS surface and the atmosphere which would create instability of the air over the UHS and lead to higher wind speeds than predicted. Thus, the NRC staff concludes that the licensee's use of a 0.3 exponent for the wind speed ratio, and the inherent instability of air over the pond make the licensee's analysis conservative with respect to wind effects.

The NRC staff found the licensee's response acceptable in that the licensee modeled wind effects conservatively in its analysis. The acceptability of the licensee's wind speed modeling was later confirmed in the NRC staff's confirmatory analysis, which found that wind speed was one of the weaker factors for peak return temperature and that natural convection plays a significant role in evaporative and convective heat transfer regardless of wind speed. The NRC staff's confirmatory analysis included a sensitivity analysis for the effects of wind speed on peak plant inlet temperature. The sensitivity analysis considered a 25 percent reduction in wind speed from both the Ryan and Brady base cases and resulted in about a 1/4 °F increase in peak temperature for Ryan and a 1 °F for Brady. The Brady wind function underestimates heat transfer, so this change is not significant.

The licensee reported that the calculated drawdown of the UHS over 30 days without makeup is 2.29 feet. The decay heat from the units used in the analysis was based on the assumption of power levels greater than the current licensed power levels. This use of elevated power levels is conservative. The licensee reported that an evaluation for net positive suction head (NPSH) was performed considering the minimum UHS water level. The evaluation showed that the available NPSH for the CSCS equipment cooling water system pumps exceeds the minimum required NPSH. Therefore, the NRC staff concludes that the UHS volume exceeds the minimum volume necessary to ensure that the minimum 30-day inventory requirement without makeup is maintained and is minimally affected by the proposed increase in UHS return temperature.

Based on the above, the NRC staff concludes that the licensee's analysis provides a basis for acceptance of the proposed TS changes, but whether the plug flow model accurately represents the UHS performance with sufficient margin to account for little margin in allowed peak UHS return temperature was subject to question by the NRC staff. The current TS limits are based on an allowed peak UHS return temperature of 104 °F during the DBA LOCA. In its LAR, the licensee used 107 °F as an upper temperature limit for UHS return temperature which is the cooling water to components cooled by CSCS. This upper limit provides very small margins for heat exchangers cooled by CSCS, e.g. 1.5 percent margin for EDG coolers and <1 percent for margin RHR heat exchangers. Due to the margins identified for heat exchangers cooled by the CSCS, the NRC staff performed an independent confirmatory analysis of the licensee's LAR.

3.2.1 Confirmatory Analysis

The NRC staff's confirmatory analysis dated June 30, 2015, (ADAMS Accession No. ML15195A055) focused on determining the key critical parameter which is the peak UHS return temperature under bounding meteorological and DBA-LOCA conditions. The confirmatory analysis used design inputs provided by the licensee, including meteorological data, plant discharged heat, CFD results, physical parameters of the UHS and the temperature limitation of 107 °F.

In the confirmatory analysis, the NRC staff examined the licensee's analyses of the peak return water temperature from the UHS pond at the LSCS site, based on its understanding of the data and phenomena involved. The confirmatory analysis concluded that the licensee's calculations of peak return water temperature are conservative, and that the proposed temperature limits for TS Section 3.7.3 is acceptable. This conclusion is based on:

- The meteorological data used by the licensee, which was determined to be appropriate for use in the UHS performance models;

- The licensee's performance models, which were determined to be conservative and accounted for the worst conditions of pond sedimentation and meteorology, and the confirmatory sensitive analyses showed that the licensee's analysis was uniformly conservative.

The NRC staff has summarized the confirmatory analysis in the Attachment to this SE

3.2.2 Summary of the Maximum UHS Temperature Evaluation.

The confirmatory analysis conducted with a mixed dispersion model and using the Ryan wind function throughout provides greater accuracy than the licensee's analysis which uses a plug flow model and the Lake Hefner wind function. The licensee's analysis predicts more severe temperature increases to the UHS under accident conditions than the confirmatory analysis. Thus, the NRC staff concludes that the licensee's analysis is conservative. Therefore, with the licensee's proposed TS as initial conditions, it provides reasonable assurance that the peak UHS return temperature will be less than 107 °F under accident conditions. Based on the above and the conservatisms in the licensee's analysis, the NRC staff concludes that there will be margin to the temperature limits for equipment and plant components cooled by the CSCS and UHS and that the licensee's proposed TS revision complies with the requirements of GDC 44 and GDC 5 and the regulatory guidelines of RG 1.27 and SRP, Section 9.2.5, and therefore, is acceptable.

3.3 Containment Performance Evaluation

LSCS, Units 1 and 2, are BWRs of the BWR/5 design with Mark- II type pressure suppression containments. As described in the LSCS UFSAR, Section 3.8.1.1.1.1, the primary containment consists of a steel dome head and post-tensioned concrete wall standing on a base mat of reinforced concrete. The inner surface of the containment is lined with steel plate which acts as a leak-tight membrane. The drywell is topped by an elliptical steel dome called the drywell head which houses the reactor and the associated primary system, in the form of a frustum of a cone, is located directly above the suppression chamber. The suppression pool chamber is cylindrical and separated from the drywell by a reinforced concrete slab. The drywell atmosphere is vented into the suppression chamber through a series of downcomer pipes penetrating and supported by the drywell floor. Four vacuum relief valves are provided between the drywell and the suppression chamber to prevent exceeding the drywell floor negative design differential pressure and back flooding of the suppression pool water into the drywell. These valves are evenly distributed around the suppression chamber air volume to prevent any possibility of localized pressure gradients from occurring due to geometry. They are mounted in special piping and located outside the primary containment and form an extension of the primary containment boundary.

One of the safety-related functions of the UHS is to provide cooling of the RHR heat exchangers during an accident and remove heat from the containment. The LSCS UFSAR provides that the maximum allowable safety-related cooling water design temperature is 107 °F.

3.3.1 Short-Term LOCA Containment Analysis

In the current short term LOCA analysis for containment pressure response, the limiting pipe break inside containment is a double-ended guillotine break of the recirculation line. In this analysis, the licensee determined that the peak drywell pressure occurs within approximately 12 seconds of the break. During this early period, the change in UHS temperature does not impact the drywell pressure response because its increase is rapidly mitigated by the containment pressure suppression system without any support from the UHS. Therefore the current peak drywell pressure of 39.9 pounds per square inch gage (psig) (as stated in UFSAR, Table 6.2-8A, and TS 5.5.13b), which is below the containment design pressure of 45 psig, is not affected by the proposed change of UHS temperature limit.

3.3.2 Long Term LOCA Containment Analysis

For the current long term containment cooling during a LOCA due to double-ended guillotine break of a recirculation line, the RHR system is manually initiated at approximately 600 seconds into the event. The RHR heat exchangers remove the required amount of heat from the suppression pool and maintain its temperature below the 200 °F limit (UFSAR, Section 6.2.3.3.1) with a maximum UHS design temperature of 107 °F. In its January 18, 2013, letter, the licensee stated that to qualify the RHR heat exchangers for the design heat removal rate with a cooling water inlet of 107 °F, a lower heat exchanger fouling resistance of 0.00147 hour(hr)-feet (ft)^2 -°F/British thermal unit (BTU) is proposed to replace its current design fouling resistance of 0.0025 hr-ft^2-°F/BTU. The licensee verified the lower value of the fouling resistance based on testing performed in response to NRC GL 89-13, "Service Water System Problems Affecting Safety-Related Equipment," utilizing the guidelines established in Electric Power Research Institute (EPRI) Technical Report 107397, "Service Water Heat Exchanger Testing Guidelines," Final Report, 1998, Section 2.2. This report has been previously accepted by the NRC as the industry standard for GL 89-13 heat exchanger performance testing. This test method allows testing at conditions far removed from limiting (design) conditions and is highly reliable as stated in Section 2.2.3, "Uncertainty" of the above EPRI report:

> ... the heat transfer test method provides for rigorous correction of the test result for differences between test conditions and limiting conditions. Therefore, the heat transfer test method more readily lends itself to a quantitative evaluation of the uncertainty of the test method. The quantitative evaluation of test uncertainty is discussed in Sections 3.9 and 5.3 and includes an evaluation of the contributions of both analysis and measurement uncertainties. As discussed in Sections 3.4.2 and 5.4.3, the uncertainty of the test result can be treated conservatively in the comparison of the test result with the acceptance criterion. The result of a heat transfer test, therefore, is highly reliable.

The licensee's most recent worst-case results for the GL 89-13 tests of the RHR heat exchangers show approximately 10 percent to 19 percent thermal margin at design conditions. Regarding test instruments, the licensee stated that multiple precision resistance temperature detectors evenly spaced around the circumference of the piping are installed with thermal paste and are also insulated during the test to minimize the effects of the surrounding environment. The licensee concluded that the as-tested RHR heat exchanger performance is significantly better than the design performance assumed in the current licensing basis containment analysis. However, the data provided in Table A5-1 of the application dated July 12, 2012, shows less than 1 percent design margin for RHR heat exchangers at 107 °F UHS temperature. The licensee informed the NRC staff that the performance of the RHR heat exchangers is monitored by the GL 89-13 program manager through thermal performance testing. If the available operating margin approaches the design margin stated in design basis analyses, the issue will be entered into the margin management program defined by procedure ER-AA-2007, "Management of Design and Operating Margins." This program tracks low design and operating margin components at the station. The items are presented to station management on a regular basis to determine actions for maintaining or improving the available design and operating margin.

Based on the licensee's testing and monitoring of the thermal capability of the RHR heat exchangers in accordance with the GL 89-13 testing and cleaning program and the margin management program provided by procedure ER-AA-2007, the NRC staff finds that the use of 107 °F as the UHS cooling water temperature for the long term containment cooling by the RHR heat exchangers is acceptable.

3.3.3 Operation of Standby Gas Treatment System

The NRC staff noted that the UHS model does not consider heat removal from the SFP during abnormal events while safety-related makeup water is provided to maintain pool level during such events. During these events, the reactor building ventilation system is isolated with an automatic start of the standby gas treatment system (SGTS). Upon the NRC staff's inquiry regarding the licensee's consideration of no heat removal from the SFP, resulting in initiation of boiling in the SFP within a few hours (UFSAR, Table 9.1-6), and subsequent steam accumulation in the reactor building, the licensee provided the following additional information in its January 18, 2013, supplement:

> As stated in RG 1.27, Revision 1, the UHS should be able to dissipate the heat from an accident in one unit and to permit the concurrent safe shutdown and cooldown of the remaining unit. The total decay heat transmitted to the UHS from the plant includes the reactor decay heat and the fuel pool decay [heat] from each unit. If the reactor decay heat is maximized, then the fuel pool decay heat would not include any recent refuel decay heat - it would be the normal decay heat in the pools with available margin for batch offloads. Conversely, if the fuel pool decay heat is maximized by assuming recent batch offloads, then the reactor decay heat would be reduced by the new fuel batch load. The LSCS UHS heat load model assumes the maximum reactor decay heat load. In addition, the LSCS model assumes the fuel pool decay heat load is dissipated by pool boiling while maintaining fuel pool level with the fuel pool emergency makeup systems instead of transmitting the energy to the UHS through pool cooling.
>
> It is not the intent of this model to alter the LSCS existing fuel pool design or licensing bases. The model assumes maximum reactor decay heat while removing a very conservative amount of UHS volume to provide for fuel pool makeup. The assumed makeup is 300 gpm for each pool (600 gpm total)

> running continuously for the entire 31-day period while the actual amount of pool water loss due to boiling would be a small fraction of such. The purpose of assuming fuel pool makeup was to reduce the UHS inventory available for accident heat rejection. The fuel pool decay heat for the LSCS model would be approximately 6E6 Btu/hr for each pool (Reference 9). Over a 48-hour period of interest, the integrated fuel pool decay heat represents approximately 4.0 percent of the total integrated UHS heat load. Over this same period of interest, the UHS volume would be reduced by over 1.5 percent due to the loss of inventory from the assumed fuel pool makeup. It is EGC's conclusion that the impact of adding the fuel pool decay heat load to the UHS and eliminating fuel pool makeup, i.e., assuming the fuel pools remain cooled and do not boil, would have an insignificant effect on the limiting initial UHS temperature profile of TS, Figure 3.7.3-1.
>
> The response of the SGTS [standby gas treatment system] to the UHS design event including the DBA LOCA with concurrent loss of offsite power remains unchanged as a result of this proposed license amendment. The ability of LSCS to maintain fuel pool cooling or to provide makeup to the fuel pools was a part of the LSCS original design and is unaffected by the proposed UHS [design] temperature limit change. The LSCS UHS model evaluates a limiting condition of accident heat load and UHS inventory loss and does not alter the design or licensing bases of the LSCS response to postulated accidents.

The NRC staff requested the licensee to confirm that the safety-related RHR system lineup for SFP cooling is available following a loss of offsite power (LOOP) and/or seismic event. The staff also requested that the licensee discuss whether the safety-related RHR alignment for SFP cooling can be accomplished for both units under design basis conditions (as LSCS, Units 1 and 2, share a common reactor building floor). In its January 18, 2013, supplement, the licensee stated that the safety-related RHR system, including all piping to and from the SFP, is available for SFP cooling following a LOOP or seismic event. In the current design, the RHR system can be cross-connected to the SFP cooling system to cool the SFP, if necessary, to maintain it at acceptable temperatures below boiling. As per UFSAR, Section 9.1.3, the NRC has accepted that the guidance of the SRP, Section 9.1.3, was met for the SFP temperatures under different conditions. The bulk SFP time to boil given in UFSAR, Table 9.1-6, was acceptable since it provided a reasonable time to allow operators to use alternative methods to cool the SFP during design-basis accidents. The humidity content of the incoming air to the SGTS of the SFP, which is not boiling, is removed by a demister and electric heater in the SGTS which is designed to process 100 percent relative humidity air.

Based on the information supplied by the licensee, the NRC staff concludes that the SGTS performance is not affected by the proposed charge because the licensee clarified that the plant design ensures that the UHS continues to remove heat from the SFP with the safety-related RHR system and maintains the SFP at the required temperature during design-basis accidents.

3.3.4 Summary of the Containment Performance Evaluation

The NRC staff concludes that with the proposed TS change:

- GDC 16 is met because the containment and associated systems will maintain an essentially leak-tight barrier against the uncontrolled release of radioactivity to the environment and will assure that the containment design conditions important to safety are not exceeded for as long as the postulated accident conditions require.

- GDC 38 is met because the containment heat removal system safety function will perform to reduce rapidly, consistent with the functioning of other associated systems, the containment pressure and temperature following any LOCA and will maintain these parameters at acceptably low levels.

- GDC 41 is met because the SGTS will perform to reduce, consistent with the functioning of other associated systems, the concentration and quality of fission products released to the environment following postulated accidents.

- GDC 50 is met because the containment structure and its internal compartments will accommodate without exceeding the design leakage rate and with sufficient margin, the calculated pressure and temperature conditions resulting from any LOCA.

-

3.4 Evaluation of Instrumentation and Controls

As described previously, the LSCS UHS consists of an excavated CSCS pond integral with the cooling lake and the piping and valves connecting the UHS with the RHR removal service water system and DG cooling water system.

There are four installed instruments used for monitoring the temperature of the lake cooling water provided to the plant. These instruments are located in the circulating water (CW) system inlet thermowells (i.e., two per unit) and provide input to the plant process computer (PPC). The outputs of these instruments are used to monitor and trend the temperature of the lake cooling water supplied to the plant via the PPC, and are used to verify the requirement of SR 3.7.3.1 at a 24-hour frequency as required by the LSCS surveillance frequency control program.

3.4.1 Setpoint

The LAR references three previously submitted documents that address the calculation of the uncertainty analysis of the UHS temperature measurement: a June 29, 2007, application for an amendment increasing the UHS limit from 100 °F to 101.25 °F; an August 1, 2007, letter supplementing this application; and the resultant amendment dated August 2, 2007, approving the increase of the UHS temperature limit to 101.25 °F (ADAMS Accession Nos. ML071830436, ML072140249, and ML072140844, respectively). The June 29, 2007, application explained that LSCS followed a graded approach for instrument channel accuracy in accordance with the licensee's procedure NES-EIC-20.04, "Analysis of Instrument Channel Setpoint Error and Instrument Loop Accuracy" (ADAMS Accession No. ML003721342). The June 29, 2007, application also provided an uncertainty analysis that concluded that the total single-channel uncertainty is not more than 0.74 °F, and that the uncertainty is not more than ±0.53 °F for a two-channel average. Based on this analysis, the licensee proposed a margin of 0.75 °F allowance for conservatism, which bounds the instrument uncertainties associated with any combination of operable temperature measurement devices to meet the requirements of SR 3.7.3.1 (ADAMS Accession No. ML072140844). The NRC staff found that the licensee had adequately addressed this area, as evidenced by the NRC staff's issuance of the amendment on August 2, 2007.

To ensure that the TS limit proposed by the current LAR remains bounded, the NRC staff reviewed the setpoint calculation to determine whether the increased range in the maximum cooling water temperatures adversely affects the loop accuracy or uncertainty of the UHS temperature instruments. However, the NRC staff did not review the methodology for the calculation of the original uncertainty analysis for the UHS temperature measurement, because this methodology was previously evaluated by the NRC staff (i.e., as a part of its issuance of the August 2, 2007 amendment) and remains unchanged.

Attachment 4 of the licensee's September 17, 2012, letter, includes LSCS Calculation L-003230, Revision 1b, "CW Inlet Temperature Uncertainty Analysis." This calculation evaluates the loop uncertainty for the CW inlet temperature indication loops for a temperature of 107 °F. Using the maximum post-accident temperature value of 107 °F, the licensee revised the values in the uncertainty analysis that were affected by increasing the CW inlet temperature. Specifically, the CW inlet temperature resulted in an increase in the resistance value from 115.013 Ω to 116.190 Ω, which is used in the calculation of the Measurement and Test Equipment Error. This increase in the resistance value resulted in a 0.001 °F increase in the Total Calibration Error (CAL2). However, the increase in CAL2 does not modify the Total Random Error, and, thus, the total single-channel uncertainty remains equal to 0.74 °F, and ±0.53 °F for a two-channel average. The calculated instrument measurement uncertainty remains the same when the CW inlet temperature indication is 107 °F, and thus EGC maintained the bounding margin of 0.75 °F allowance for conservatism. Based on this information, the NRC staff found that the licensee has considered the effect of increased UHS temperature in the plant design and determined that it does not affect the current licensing basis and continues to meet the requirements of 10 CFR 50.36, GDC 13, and the guidance of RG 1.105.

The application explains that the current TS limit includes 0.3 °F conservatism, which was determined from the UHS limiting initial temperature of 102.3 °F and to ensure that the maximum post-accident temperature of 104 °F is not exceeded (for information about this limit refer to TS Bases, Section B 3.7.3, and LSCS Calculation L-002457, Revision 5, "LaSalle County Station Ultimate Heat Sink Analysis," which were evaluated during the 2007 NRC staff review (ADAMS Accession No. ML072140844)). The proposed modification to the TS limit to vary with the diurnal cycle increases the conservatism to 0.42 °F because the increase of the maximum UHS design temperature to 107 °F and the difference between the maximum projected UHS temperature during the day and the proposed TS limit (Table 2 of the LAR), including instrument uncertainty for single channel (0.75 °F).

3.4.2 Summary of the Evaluation of Instrumentation and Control

The NRC staff reviewed the licensee's application related to the effects of changing the TS limit on the UHS inlet temperature from the present value of 101.25 °F to a value of 104 °F. The NRC staff concludes that the licensee demonstrated that the calculated instrument measurement uncertainty remains the same when the CW inlet temperature indication is 107 °F. In particular, modifying the TS limit on the UHS temperature from the present value of 101.25 °F to values varying with the diurnal cycle up to a maximum of 104° F will not adversely affect the loop accuracy or uncertainty of the UHS temperature instruments. Furthermore, the NRC staff concludes that the systems will continue to meet the requirements of 10 CFR 50.36, and GDC 13. Therefore, the NRC staff finds the licensee's proposed modification acceptable with respect to instrumentation and controls.

3.5 Evaluation of Operator Actions Added, Changed, or Deleted

As a part of LAR, the licensee proposes the additional operator action of monitoring the UHS temperature (cooling water temperature) once per every hour using the main control room plant process computer. In addition, the operators will have to log and compare the condenser water inlet temperature from both units to the TS allowable water temperature, using proposed TS, Figure 3.7.3-1, as opposed to the existing single limiting value of 101.25 °F. This additional action is estimated to take control room operators less than two minutes to perform and is stated to not create any undue burden. The NRC staff has reviewed this additional action and has determined that it is acceptable because it will not create any additional burden.

The NRC staff determined that the only aspect of the additional action requiring reanalysis is the increase in the frequency of monitoring performed by the operator. This operator action is considered to be a simple action and the estimated time to perform the action is negligible (i.e., less than two minutes per hour). Additionally, the licensee's review did not identify any changes that would appreciably impact the time for the monitoring and recording of the UHS temperature in accordance with Procedure LOS-AA-S101 (201). The NRC staff concludes that the additional workload to the operators will not prevent them from accomplishing this task and that there is no additional support needed.

Monitoring, recording, and comparing the temperature of the condenser water inlet temperatures to the TS allowable water temperature as required by proposed TS 3.7.3, Action B.1, is within the capability of normal control room staffing. No new or additional qualifications would be required to perform the action sequence. The NRC staff concludes that no additional staffing or qualifications, or changes thereto, are required, and finds this change acceptable.

The licensee has stated that three procedures will be revised as a result of the granting of the proposed amendment. *LOS-AA-S101 (S201) Unit 1 (Unit 2), "Shiftly Surveillance," and EN-LA-402-0005, "Extreme Heat Implementation Plan – LaSalle,"* will be revised to refer to proposed TS Figure 3.7.3-1 for UHS operability temperature limits as a function of time of day. LIP-CW-501 (601) U1 (U2), "Condenser Circulating Water Inlet Temperature (Line A and B) Calibration," will be revised to initiate the main control room plant process computer alarm at 101 °F. The NRC staff concludes that the revisions to the procedures are adequate and would support the proposed amendment.

The licensee has stated that, prior to implementation of the proposed changes, operators will be trained on the revised procedures and proposed TS 3.7.3, Required Action B.1, which would require verifying that cooling water temperature is within TS limits when the cooling water temperature is greater than or equal to 101 °F once every hour. The operator response to high cooling water temperature would not change. The training on the revised procedures would not cause operator burden or change response time. Therefore, the NRC staff concludes that the required training will be given to the appropriate staff to meet the objectives to support the proposed amendment.

3.5.1 Summary of Operator Actions Added, Changed, or Deleted

The NRC staff concludes that the proposed amendment is acceptable with respect to human performance based on the information provided by EGC that the resultant changes to operator actions would be minor and would not create any undue burden or need for additional support. The procedures and training will adequately incorporate the changes prior to their implementation to fully support the proposed amendment.

3.6 Conclusion – Technical Evaluation

Based on the above, the NRC staff concludes that with the proposed amendment, GDCs 5, 16, 38, 41, 44, and 50 will continue to be satisfied.

4.0 STATE CONSULTATION

In accordance with the Commission's regulations, the Illinois State official was notified of the proposed issuance of the amendment. The State official had no comments.

5.0 ENVIRONMENTAL CONSIDERATION

The NRC staff published an Environmental Assessment (EA) in the *Federal Register* on August 3, 2015 (80 FR 46062) related to this proposed action. In that EA, the NRC staff concluded that the proposed action would not have a significant effect on the quality of the human environment. Accordingly, the NRC staff determined that an environmental impact statement was not warranted for the proposed action.

6.0 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.

Attachment - Summary of the Confirmatory Analysis

Principal Contributors: Rossnyev Alvarado
Russell Chazell
DaBin Ki
Gerard Purciarello
Ahsan Sallman

Date of issuance: November 19, 2015

ATTACHMENT

SUMMARY OF THE CONFIRMATORY ANALYSIS

Description of the Confirmatory Analysis

The confirmatory analysis focused on determining the key critical parameter which is the peak ultimate heat sink (UHS) return temperature under bounding meteorological and design basis accident and loss-of-coolant accident (DBA-LOCA) conditions. The confirmatory analysis used design inputs provided by the licensee, including meteorological data, plant discharged heat, computational fluid dynamics (CFD) results, physical parameters of the UHS and the temperature limitation of 107 °F.

The meteorological data from the licensee came from the LaSalle County Station (LSCS) site and Peoria, IL, for the years 1995-2010, and from Peoria, IL, and Springfield, IL, for the years 1948-1996. The primary meteorological data was prepared from the only data available from the LSCS site, (i.e., wind speed and direction and dry bulb temperature and all other data from the Peoria site). The confirmatory analysis performed data comparison studies and concluded that on average, Peoria has higher air temperatures and lower wind speeds than LSCS and that the licensee's use of offsite data was reasonable, and essential to the calculation of UHS performance. The confirmatory analysis performed a sensitivity study of the various meteorological parameters on peak pond temperature to determine the order of greatest thermodynamic effect. The order of greatest effect is (i) dew point temperature, (ii) solar radiation, (iii) cloud cover, and (iv) wind speed, in that order. The licensee had determined that the more severe data with respect to peak UHS temperature occurred in the 1995-2010 set, while the worst meteorological data for ensuring a 30-day supply occurred in the 1948-1996 data set. The confirmatory analysis used the May through September data from the LSCS/Peoria set as the range of data for computational purposes. It used the Peoria/Springfield data in a separate sensitivity study explained later.

The confirmatory analysis developed two models, referred to as LAPLUG, using the guidelines of NUREG 0693, "Analysis of Ultimate Heat Sink Cooling Ponds." The first pond configuration (Model A) had 30 segments. Segment 1 of Model A had a volume and surface area 25 percent of the total volume and area to account for mixing in the discharge region. Segments 2–30 had the remaining volume and area. The second pond configuration (Model B) had 38 segments. This model configuration was developed to consider the large differences in the depth of various parts of the pond, which varies from 3.5 feet (most of the pond), and the intake canal and a transition area between the shallow pond and the canal having a depth of up to 10 feet. The licensee's model, LAKET-PC, makes the assumptions of an idealized rectangular channel with width and depth constant for all segments (Calculation No. L-002457, Revision 8, Attachment N, page N9). LAKET-PC appears to assume that hot water entering the pond moves from the discharge location to the intake in discrete plugs with no mixing with other pond water. In some cases, plug flow is an efficient process because it keeps the hot water and cooler initial pond water from mixing, thereby, maximizing the heat transfer of the water with the atmosphere. However, it can also be highly unrealistic in an irregularly shaped pond, which would have mixing processes and multiple pathways with different travel times between the discharge and intake. These processes would lead to the spreading out of the heat pulse and dilution of the hot water with the cooler pond water, which would reduce the magnitude of peak temperature. The NRC staff believed that the licensee's use of the plug flow model, although conservative in this case, was unrealistic for an irregularly shaped pond that would have mixing processes and multiple pathways. LAPLUG is not a strictly plug flow model, but assumes that the pond consists of a series of 38 well-mixed volumes as "mixed-tanks in series." An illustration of the differences in methodology between plug flow and mixed flow is provided in Figures A5 and A6 of the confirmatory analysis. LAPLUG accounts for mixing caused by turbulence and bottom friction, which tends to reduce the peak temperature. The confirmatory analysis constructed a simplified example to illustrate the differences between plug flow and mixed tank models. The example consists of a 30 equal size segmented pond modeled as both a plug flow and a mixed tank model. Each model has a heat addition rate based on a curve fit of the actual LSCS heat rate, a constant flow rate through the pond, and constant meteorology. The intent here is to illustrate the effect of dispersion and mixing on peak temperature, isolated from confounding effects of a varying meteorology and varying flow rate. Figure A7 represents the differences between a plug flow model and a model that allows dispersion and mixing, which illustrates that the plug flow model predicts a higher UHS peak temperature than the dispersion model.

LAPLUG models the change in peak UHS temperature by accounting for the heat added by the plant and the gains and losses of heat exchanged with the environment as a function of time. The environmental heat exchange factors are solar or short-wave radiation, long-wave or infrared radiation from the atmosphere and clouds, back-radiation of infrared heat from the water to the atmosphere and sky, convection of air in contact with the water surface, and evaporation or latent heat exchange. These terms are shown graphically in Figure A11 of the confirmatory analysis. The most significant difference between the licensee and the confirmatory analysis heat transfer models is the use of a term known as the wind function, which appears in the heat transfer terms for evaporation, "H_E," and convection, "H_C," and defines how heat energy is carried away from the water surface by the wind and thermally induced convection. Both the LAKET-PC and LAPLUG models use the standard formulation from Ryan and Harleman. The confirmatory analysis also uses the more conservative Brady wind function for sensitivity analyses discussed later. The licensee used the natural lake temperature as an indicator to switch between two wind functions; the Ryan wind function for heated water bodies and an alternative "Lake Hefner" wind function for unheated water bodies that is dependent only on wind speed. The licensee used the Lake Heffner wind function when UHS surface temperature was within 2.5 °F of natural lake temperature. The confirmatory analysis did not switch to a Lake Hefner wind function. The confirmatory analysis found no justification for the licensee's use of natural temperature to switch the form of the wind function. The extensive review of wind functions by Ryan and Harleman (1973) and Helfrich, et al. (1982) shows superior performance of the Ryan function over other approaches for a wide variety of conditions of heated and unheated bodies of water. The licensee's use of the alternative wind function (Lake Hefner), which underestimates thermal convection, might be especially adverse for cases where wind speed is small or zero, leading to the unlikely prediction of no evaporation. Since evaporation has usually been shown to be the largest heat transfer term, according to the U.S. Nuclear Regulatory Commission (NRC) staff, this is especially inappropriate. However, the licensee's use of the Lake Hefner wind function is conservative because it predicts less heat loss from the UHS to atmosphere.

The licensee had performed a highly detailed CFD model with the intention of determining the effective surface area and volume of the UHS for the licensee's LAKET-PC model. The confirmatory analysis stated that the CFD model had some limitations by assuming identical fluid properties for the pond water and the heated water discharged from the plant. This assumption did not account for the possibility of stratification but assumed, based on pond number calculation, that the pond would not be stratified since the licensee plug flow model depends on a non-stratified pond. Nevertheless, the CFD model proved useful to the confirmatory analysis models by providing effective volume and surface values and showing mixing in the discharge region and arrival time distribution. The CFD model illustrates the jet formed in the lower left quadrant of the pond, extending out into the center of the pond as shown in Figure A8. The high-velocity jet induces considerable recirculation, resulting in mixing and considerable entrainment of cooler pond water that diminishes the possibility of strong stratification in the pond. On this basis, the confirmatory analysis assumed that the first segment of its model would be well-mixed and have a uniform temperature. It included a large (25 percent) mixing zone in the base-case analysis. The licensee's CFD model also shows that the heated water arrives at the intake structure as a distribution rather than a constant as would be the case in true plug flow. Figure A10 of the confirmatory analysis illustrates a distribution of intake temperature in a modified version of LAPLUG developed solely to illustrate arrival time distribution. The NRC staff believes that there is sufficient justification to assume that the pond would not be significantly stratified from the effects of heated discharge and that if there was stratification caused by solar heating, water would be mixed in the deep intake canal negating the effects of limited stratification. Because of other CFD limitations as mentioned in its report, the NRC staff performed sensitivity studies by varying both effective volume and surface area by 10% and also by 25 percent. As expected, the peak UHS return temperature was unchanged from the base Ryan model because the peak temperature is caused by environmental heating only as shown by initial computer runs. The more conservative Brady case shows larger peak temperatures because the peak temperature is influenced by the heat from plant discharge water.

The confirmatory analysis models accounted for the effects of dispersion between model segments and effective mixing in the area of discharge. Initial computer runs made clear that the peak return temperature calculated by the model was not caused by rejecting heat from the plant but by the natural heat exchange with the plant environment. The NRC staff performed analysis of peak return temperature using both Model A (30 segments) and Model B (38 segments). The first segment of Model A was 25% of the volume as a result of the high velocity discharge with the remaining segments of equal size and were chosen to allow 86 CFS (ft^3/sec) of discharge in 1 hour. Pond depth was 4.57 feet (volume divided by area). Model B consisting of 38 segments was an attempt to account for differences in depth. Most of the depth as modeled has a depth of 3.5 feet with the transition area having a depth up to 10 feet. Since environmental factors were the most significant as compared to plant heat input, shallow areas are affected differently than deeper areas. The confirmatory analysis used a wind speed reduction factor of 0.8 for adjusting wind speed data because measurements were taken at 10 meters whereas the Ryan wind function needs wind speed at 2 meters. The 0.8 reduction factor was derived from the licensee's wind tunnel testing data [Attachment 6 of EGC letter dated October 4, 2013], which found an average wind power law exponent of 0.135. The wind power law exponent of 0.135 corresponds to a 0.8 wind reduction factor. Using a 0.8 reduction factor was less conservative than the licensee's approach, which used a wind power law exponent of 0.3 which computes to a wind speed reduction of 0.62. The confirmatory analysis later performed wind speed sensitivity analyses with a 25% reduction in wind speed that corresponds to a 0.6 wind speed reduction factor which is more conservative than the licensee's value of 0.62. The confirmatory analysis used 104 °F as the starting temperature for all runs of the models since 104 °F was the highest technical specification (TS) limit proposed by the licensee. The confirmatory analysis also used the maximum sediment level of 18 inches for all case runs since that represented the limiting conditions. Also, the confirmatory analysis ran its models through the entire set of weather data for the months of May through September, starting at every 3-hour interval, instead of finding a limiting set of meteorological data. This is different than the licensee' approach, which first determined limiting weather data, then ran its LAKET-PC model through what had been determined to be limiting weather data. Figure A16 and A17 show the results of Model A, which also show lack of sensitivity of peak return temperature to plant heat load and flow rate. The peak return temperature was 105.58 °F and occurred approximately 6 hours after the DBA for the worst-case DBA start time. Plant heat was dissipated before it reached the intake structure. Model B attempted to take into account varying depth. Model B is a more accurate representation of a non-stratified pond. Peak return temperature occurred approximately 7 hours after the DBA at 105.04 °F. Figure A20 shows the peak return temperature for Model B with and without the heat load and the return temperature for the 30 days after the DBA. Figure A20 from Model B which uses the Ryan-Harleman heat transfer relationships and the licensee's meteorological data set is the best estimate of pond performance and serves as the base case for comparison to the sensitivity analysis discussed next.

The NRC staff performed a set of sensitivity analyses to determine the effect of significant variance of individual design input and assumptions upon peak UHS return temperature. Since the models and data have uncertainty, the sensitivity analyses help determine whether there should be concern for the lack of certainty of various input and assumptions. All sensitivity analyses were performed with an initial temperature of 104 °F which is higher than the proposed TS limit for the time of day which produces the highest peak UHS return temperature. Sensitivity analyses were performed for two case runs at 104.75 °F, which would include instrument uncertainty. A sensitivity analysis was performed using the alternate Brady wind function. The peak return temperature was 106.1 °F about 36 hours after DBA which approximately coincides with the plant heat reaching the intake structure, which is similar to the licensee's results. As previously stated, the Brady wind function is over conservative. With peak return still being less than 107 °F, this analysis adds reliability to the base case that uses the Ryan wind function. Sensitivity runs were performed by using the following parameters for individual runs for both the Brady and Ryan wind function: a 2 foot stratified layer, Model A 30, equal segments, 1948-1996 weather data, reduced mixing volume of first segment, 25 percent reduction in wind speed, 10 percent reduction in surface area and volume, 25 percent reduction in surface area and volume, add 2 °F to dry bulb and 1.6 °F to dew point to account for more severe weather, and 50 percent increase in heat load. The temperature values for more severe weather adds some margin for possible long-term climatic change resulting from human or natural causes. All sensitivity runs yielded peak UHS temperatures less than 107 °F except for the Brady wind function with a 25 percent reduction in wind speed, wind function with a 10 percent and 25 percent reduction in volume and surface area, and the wind function with 150 period heat load. As previously stated, though the Brady wind function largely underestimates heat loss to the environment. Coupled with the added adverse parameters, the results of these few sensitivity runs do not invalidate the conservatism of the confirmatory analysis model findings of peak UHS temperature of less than 107 °F.

<u>Confirmatory Analysis Conclusion</u>

The confirmatory analysis report made the following conclusions:

- Independent confirmatory analyses predict similar or smaller temperature rise than those of the licensee for runs starting at 104 °F.

- The use of offsite data from Peoria and Springfield is reasonable and justified based on partial correlations of onsite and offsite air temperature and wind speed.

- The licensee's adjustment of dew point temperatures from Peoria so they cannot exceed dry bulb temperatures from LSCS is appropriate.

- The licensee is justified in assuming the pond is unstratified from the effects of hot water addition. Pond may become stratified as a result of environmental heating enhanced by turbidity, but this would not affect the peak return water temperature significantly. The assumption of no stratification also conservatively neglects the additional heat transfer caused by higher surface temperature and through thermally induced circulation into dead-end spaces in the pond.

- For the Ryan wind function model, the discharge of heated water to the pond does not affect the highest peak return water temperature.

- The Ryan and Harleman heat transfer relationships are the preferred heat transfer model for estimating peak return water temperature, even though this approach has been shown to overestimate cooling in some cases. Use of a more conservative model, such as Brady heat transfer model, can underestimate cooling by a large margin.

- The licensee's model approach to the wind factor (i.e., use of "natural temperature"), and a no dispersion or mixing also would lead to an increased peak return water temperature. However, the NRC staff could find no justification for using these approaches other than they add conservatism to the temperature calculations.

- The NRC staff's sensitivity experiments for a strongly stratified pond do not result in an increased peak return temperature.

- The NRC staff's sensitivity experiments with decreased surface area and volume for the pond demonstrate essentially no increase in return water temperature when using the preferred Ryan model. Use of the Brady model predicts higher return water temperatures, but NRC staff believes the Ryan result is more accurate.

- The NRC staff's sensitivity experiments with a decreased wind speed reduction factor of 0.6, which is 25 percent less than the base case, demonstrates only a small increased return water temperature for the preferred Ryan model. Return water temperature with the Brady model is higher, but NRC staff believes the Ryan result is more accurate. Results with even more severe wind speed reduction factor of 0.43 were still below

107 °F.

- The NRC staff's sensitivity experiments that increased heat load by 50 percent resulted in no increase in peak return temperature (for Ryan).

- The higher values of the licensee's predictions of peak return water temperature can be explained by the licensee's use of a no-dispersion model and natural temperature to switch between two forms of the wind function. However, NRC staff believes its results are more realistic and accurate.

The NRC staff developed a more precise model than the licensee. The licensee used a one dimensional plug flow model, whereas the NRC staff used modeling that takes into account mixing and dispersion into the cooler ambient water. Additionally, the confirmatory analysis models do not use the Lake Hefner wind function as the licensee did for small (<2.5 °F) temperature differences between natural lake temperature and surface temperature. The confirmatory analysis used meteorological data and heat input provided by the licensee, but developed its own unique transient modeling of UHS performance. Significant differences between the licensee's model called LAKET-PC and the confirmatory analysis model called LAPLUG include dispersion and heat transfer modeling. The licensee's code uses a no-dispersion model that assumes the movement of parcels of water in plug flow through the pond, with no mixing or dispersion into cooler ambient pond water. The licensee's model uses a form of the atmospheric heat transfer formulas that can significantly underestimate heat transfer from natural convection ("natural temperature" approach) by using the Lake Hefner wind function. Both of these factors potentially lead to higher return water temperature. The confirmatory analysis concluded that with the specified heat loads and other pond parameters, and using the preferred Ryan and Harleman (1973) atmospheric heat transfer relationships, peak return temperature is essentially independent of heat rejected from the plant for reasonable combinations of parameters. Through model experimentation, the confirmatory analysis concluded that differences between the licensee's predictions and the confirmatory analysis predictions can be attributed to the licensee's use of the no-dispersion model and the natural temperature approach for atmospheric heat transfer. With initial UHS temperature higher than that of the proposed TS, the confirmatory results were uniformly less severe than the licensee's, and thus it can be concluded that the licensee's analysis is conservative and acceptable.

Your letters dated October 4, 2013, and December 4, 2014, and April 15, 2015, contained proprietary information. The NRC staff believes that the enclosed SE does not contain proprietary information. Nevertheless, the NRC staff will withhold public disclosure of this entire amendment package for 14 days from the date of issuance to allow you time to review the package. Please inform me within this period if you have any concerns regarding proprietary information.

Sincerely,

/RA/

Bhalchandra Vaidya, Project Manager
Plant Licensing III-2 and
Planning and Analysis Branch
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-373 and 50-374

Enclosures:
1. Amendment No. 218 to NPF-11
2. Amendment No. 204 to NPF-18
3. Safety Evaluation

cc w/encls: Distribution via ListServ

DISTRIBUTION:
PUBLIC
RidsOgcRp Resource
RidsRgn3MailCenter Resource
RidsAcrs_MailCTR Resource
RidsNrrLASRohrer Resource
LPL3-2 R/F
RidsNrrDirsItsb Resource
RidsNrrDorlDpr Resource
RidsNrrLASRohrer Resource
RidsNrrPMLaSalle Resource
RidsNrrDorlLpl3-2 Resource

Amendment Accession No. **ML15202A578**
*Memo of 1/15/15 (ML15008A327)
**Memo of 1/10/13 (ML13002A337)
***Memo of 7/7/14 (ML14182A155)
****Memo of 7/14/15(ML15195A229)

* via e-mail

NAME	LPL3-2PM	LPL3-2LA	SBPB/BC*	SCVB/BC*	EICB/BC*	STSB/BC
OFFICE	BVaidya	SRohrer	GCasto	RDennig	JThorp	RElliott
DATE	11/19 /15	11/17/15	7/14/15	1/15/15	1/10/13	7/27/15

NAME	APHB/BC(A)	SNPB	OGC	LPL3-2/BC
OFFICE	DChung	JDean	JWachutka	TTate
DATE	7/7/14	7/20/15	11/18/15	11/19/15

OFFICIAL RECORD COPY