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10 CFR 50
10 CFR 51
10 CFR 54

RS-14-097

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U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555-0001

Braidwood Station, Units 1 and 2
Facility Operating License Nos. NPF-72 and NPF-77
NRC Docket Nos. STN 50-456 and STN 50-457

Byron Station, Units 1 and 2
Facility Operating License Nos. NPF-37 and NPF-66
NRC Docket Nos. STN 50-454 and STN 50-455

Subject: Responses to NRC Requests for Additional Information, Set 14, dated March 18, 2014, related to the Braidwood Station, Units 1 and 2, and Byron Station, Units 1 and 2, License Renewal Application

References: 1. Letter from Michael P. Gallagher, Exelon Generation Company LLC (Exelon) to NRC Document Control Desk, dated May 29, 2013, "Application for Renewed Operating Licenses."

2. Letter from Lindsay R. Robinson, US NRC to Michael P. Gallagher, Exelon, dated March 18, 2014, "Requests for Additional Information for the Review of the Byron Station, Units 1 and 2, and Braidwood Station, Units 1 and 2, License Renewal Application, Set 14 (TAC NOS. MF1879, MF1880, MF1881, AND MF1882)

In the Reference 1 letter, Exelon Generation Company, LLC (Exelon) submitted the License Renewal Application (LRA) for the Byron Station, Units 1 and 2, and Braidwood Station, Units 1 and 2 (BBS). In the Reference 2 letter, the NRC requested additional information to support the staffs' review of the LRA.

Enclosure A contains the responses to these requests for additional information.

Enclosure B contains updates to sections of the LRA (except for the License Renewal Commitment List) affected by the responses.

Enclosure C provides an update to the License Renewal Commitment List (LRA Appendix A, Section A.5). There are no other new or revised regulatory commitments contained in this letter.

If you have any questions, please contact Mr. Al Fulvio, Manager, Exelon License Renewal, at 610-765-5936.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on 4-17-2014

Respectfully,

Michael P. Gallagher
Vice President - License Renewal Projects
Exelon Generation Company, LLC

Enclosures: A: Responses to Requests for Additional Information
B: Updates to affected LRA sections
C: License Renewal Commitment List Changes

cc: Regional Administrator – NRC Region III
NRC Project Manager (Safety Review), NRR-DLR
NRC Project Manager (Environmental Review), NRR-DLR
NRC Senior Resident Inspector, Braidwood Station
NRC Senior Resident Inspector, Byron Station
NRC Project Manager, NRR-DORL-Braidwood and Byron Stations
Illinois Emergency Management Agency - Division of Nuclear Safety

Enclosure A

Byron and Braidwood Stations (BBS), Units 1 and 2
License Renewal Application
Responses to Requests for Additional Information

RAI B.3.1.2-1
RAI B.3.1.2-2
RAI B.2.1.34-1
RAI B.2.1.30-1
RAI B.2.1.30-2
RAI B.2.1.30-3
RAI B.2.1.30-4
RAI B.2.1.29-1
RAI B.2.1.29-2

RAI B.3.1.2-1

Applicability:

Byron Station (Byron) and Braidwood Station (Braidwood), all units

Background:

License renewal application (LRA) Section B.3.1.2 states that the "Concrete Containment Tendon Prestress" aging management program (AMP) is consistent with an enhancement with the Generic Aging Lessons Learned (GALL) Report, Revision 2, AMP X.S1, "Concrete Containment Tendon Prestress." The "monitoring and trending" program element of the GALL Report AMP X.S1 states that "the trend line represents the trend of prestressing forces based on the actual measured forces" and that NRC Information Notice (IN) 99-10, "Degradation of Prestressing Tendon Systems in Prestressed Concrete Containments," provides guidance for constructing the trend line.

LRA Section B.3.1.2 also states that the "[t]rend line regression analysis is consistent with NRC Information Notice (IN) 99-10." The LRA further states that the "[t]rend lines, one for each tendon group, are constructed using the measured tendon forces and represent the changes in mean vertical, hoop and dome prestressing forces with time" and that "the analysis evaluates force trends by group (dome, hoop, vertical) and shows that group mean forces will not fall below applicable [minimum required values] MRV's prior to the end of the period of extended operation."

Issue:

Table IWL-2521-1 in Subsection IWL of the ASME Code, Section XI, states that for each tendon group the number of tendons to be examined varies between 2 to 5 percent of the tendon population. IN 99-10 discusses that for a small sample size, using the average of the tendon force (TF) for each surveillance test masks the true variation between TF and time (T) (i.e., the tendency of the TF to vary systematically with T, where the scattering of points about the "curve" represents the true relationship between TF and T). The staff noted that LRA Figures 4.5-1 through 4.5-12 show that multiple tendon values are plotted for past inservice inspection (ISI) years. It is not clear whether the applicant uses average/mean TF or individual lift-off values when developing the trend lines.

Request:

Clarify the methodology used for the construction of the regression analysis. Specifically, state whether the Byron and Braidwood regression analyses use the individual lift-off forces for the development of statistically validated trend lines.

<u>Exelon Response</u>:

The methodology used in the construction of the tendon prestress regression analyses utilizes lift-off force values for each individual tendon measured during each examination. Specifically, each individual tendon lift-off force for a tendon group (e.g., dome, hoop, vertical) measured during each examination is plotted. For each tendon group, a best-fitting linear line is applied to the entire population of data points to form a trend line. This methodology of utilizing individual tendon force values is consistent with NRC IN 99-10, and is described in LRA Sections 4.5, A.3.1.2, A.4.5, and depicted in LRA Figures 4.5-1 through 4.5-12.

The use of the term "mean", in the LRA Appendix B.3.1.2 excerpts referenced in the *Background* section of this RAI, was not intended to imply that the methodology applied to the construction of regression analyses for Byron and Braidwood used, "…the average of the [tendon force] for each surveillance test...", as cautioned against in NRC IN 99-10. Rather, since the loss of prestress rate in individual tendons within a tendon group is not uniform for all tendons, plotting and trending the lift-off force values of different individual tendons each surveillance, with the exception of one control tendon in each group, provides a representation and indication of the "average loss of prestress" phenomenon over time associated with the overall group. The referenced wording contained in the original LRA Appendix B, Section B.3.1.2, was intended as a characterization of what the regression analysis trend lines represent, not a description of the methodology utilized to construct the lines.

In order to clarify the methodology applied to the construction of the regression analyses for Byron and Braidwood Stations, LRA Section 4.5 and Appendix B, Section B.3.1.2, are revised as shown in Enclosure B of this letter to remove descriptors that may imply that the methodology incorporates average force values.

RAI B.3.1.2-2

Applicability:

Byron and Braidwood

Background:

LRA Section B.3.1.2 states that the "Concrete Containment Tendon Prestress" AMP is consistent with an enhancement with the GALL Report, Revision 2, AMP X.S1, "Concrete Containment Tendon Prestress." The GALL Report AMP X.S1, in its program description, states that "[t]he program consists of an assessment of inspections performed in accordance with the requirements of Subsection IWL of the ASME Code, Section XI, as supplemented by the requirements of 10 CFR 50.55a(b)(2)(viii)" and that the parameters monitored are the prestressing TF in prestressed concrete containments.

LRA Section B.3.1.2 states that "[t]he program requires measurement of prestressing forces on an initial 2% sample of each tendon group (dome, hoop, vertical) every five years, as specified in IWL-2400." The LRA also states in the "operating experience" program element:

> In 2009 and 2011, Byron and Braidwood, respectively, performed the 25th year interval ASME Section XI, Subsection IWL, examinations of the concrete containment tendons. These examinations included testing to assess the loss of prestressing forces in select containment tendons, consistent with IWL requirements.

Issue:

The audited procedure ER-AA-330-006, "ISI and Testing of the Prestressed Concrete Containment Post Tensioning System, Rev. 6," indicates that Byron and Braidwood alternate every ten years between visual and full examinations which include testing and measurements of TF. Subsection IWL-2421 of Section XI of the ASME Code allows the examination frequency to be modified if the containments are essentially identical in design, utilize the same prestressing systems, and post tensioning operations were completed within two years apart. If all criteria are met, then full examinations as required by IWL-2500 shall be performed at 1, 3, and 10 years and every 10 years thereafter for the first containment unit; and for each subsequent containment constructed at the site, examinations shall be performed at 1, 5, and 15 years and every 10 years thereafter. It is not clear whether Byron and Braidwood follow the modified ISI intervals as stated in IWL-2421 and procedure ER-AA-330-006 to perform measurement of TF at alternating time frames for each unit (e.g., one unit fully examined per IWL-2500 on year 20 while the other on year 25) or examines, tests, and measures TF for both units at each site every five years, as stated in the LRA.

Request:

Clarify the frequency of measuring the prestressing tendon forces for each selected tendon group (dome, hoop, vertical) sample examined during ISIs for Byron and Braidwood, all units.

Exelon Response:

The frequency of measuring the tendon prestressing forces for each selected tendon group (dome, hoop, vertical) sample is in accordance with the approved Byron and Braidwood In-Service Inspection (ISI) program testing requirements. Prior to the 15th year Containment In-Service Inspection (CISI) examinations, the CISI examination frequency was in accordance with the modified frequency for multi-unit sites specified in RG 1.35, "Inservice Inspection of Ungrouted Tendons in Prestress Concrete Containments." Beginning with the 15th year CISI examinations, the CISI examination frequency has been in accordance with the modified ISI interval stated in IWL-2421. As such, tendon force measurements of each selected tendon group (dome, hoop, vertical) sample are currently performed once every ten (10) years per unit at each site, with the tendon force measurements for each unit being out of phase by five (5) years with respect to the other unit. Examinations performed at either Byron or Braidwood are not, however, credited for the other site.

Based upon this examination frequency, prestressing tendon force measurements for each selected tendon group sample have been performed on both Byron Unit 1 and Braidwood Unit 1 at 1, 5, 10, and 20 years after the initial Structural Integrity Test (SIT). Prestressing tendon force measurements have been performed on both Byron Unit 2 and Braidwood Unit 2 at 1, 5, 15, and 25 years after the initial SIT. A few additional tendon force examinations beyond those required by RG 1.35 and IWL-2421 have also been performed at Braidwood, Units 1 and 2. These individual values have been accounted for in the periodically updated regression analyses. While full examinations required by IWL-2500, including tendon force measurements, are conducted every ten (10) years at each unit, visual examinations required by IWL-2524 and IWL-2525 are still performed every five (5) years at each unit. This is further depicted in the table provided below.

Beginning with the 10th year following initial SIT, IWL-2410 and IWL-2420 provide a plus or minus one year margin relative to the specified date by which visual only and tendon force measurement examinations should be completed at each unit. Since each of the two units at both Byron and Braidwood meet the criteria set forth in IWL-2421 for multi-unit sites, this has allowed performance of the required IWL examinations at each sites' two units during the same year (e.g., full IWL-2500 examinations at one unit, and IWL-2524 and IWL-2525 examinations at the other unit). Therefore, as stated in the operating experience example for the Concrete Containment Tendon Prestress (B.3.1.2) aging management program, the 25th year ASME Section XI, Subsection IWL, examinations were performed in 2009 at Byron, and in 2011 at Braidwood. As can be seen in the table below, full examinations required by IWL-2500, including prestressing tendon force measurements for each selected tendon group (dome, hoop, vertical), were performed at Byron Unit 2 and Braidwood Unit 2. Only those examinations required by IWL-2524 and IWL-2525 were performed in 2009 at Byron Unit 1 and in 2011 at Braidwood Unit 1.

In order to further clarify the current tendon examination schedule at Byron and Braidwood, the following table is provided to depict the ASME Section XI, Subsection IWL recently completed and scheduled examinations:

Year	Byron U1	Byron U2	Braidwood U1	Braidwood U2
2004	20th Yr Full IWL-2500	20th Yr IWL-2524 & IWL-2525		
2006			20th Yr Full IWL-2500	20th Yr IWL-2524 & IWL-2525
2009	25th Yr IWL-2524 & IWL-2525	25th Yr Full IWL-2500		
2011			25th Yr IWL-2524 & IWL-2525	25th Yr Full IWL-2500
2014	30th Yr Full IWL-2500	30th Yr IWL-2524 & IWL-2525		
2016			30th Yr Full IWL-2500	30th Yr IWL-2524 & IWL-2525
2019	35th Yr IWL-2524 & IWL-2525	35th Yr Full IWL-2500		
2021			35th Yr IWL-2524 & IWL-2525	35th Yr Full IWL-2500

RAI B.2.1.34-1

Applicability:

Byron and Braidwood

Background:

LRA Section B.2.1.34 states that the "Structures Monitoring" AMP is consistent with enhancements with the GALL Report, Revision 2, AMP XI.S6, "Structures Monitoring." During a walkdown of Byron and Braidwood's main steam and tendon gallery tunnels, the staff observed white material deposits, or efflorescence, on some below-grade reinforced concrete walls. The conditions at Byron are far more evident than at Braidwood. A review of operating experience revealed similar conditions in the auxiliary feedwater tunnel concrete walls. Through discussions with the applicant, the staff learned that the cracks through which the material appears to be leaching have existed since initial plant construction, and the material deposits are considered to be the result of the limestone backfill migrating through these cracks. The staff noted that the groundwater at both Byron and Braidwood is considered to be an aggressive environment due to high chloride levels (i.e., >500 ppm).

Issue:

10 CFR 54.21(a)(3) requires that the applicant demonstrate that the effects of aging will be adequately managed so that the intended function will be maintained consistent with the current licensing basis for the period of extended operation. However, without knowing the source of the material deposits in the main steam, auxiliary feedwater, and tendon gallery tunnels (i.e., whether the material deposits are a result of the limestone backfill migrating through the cracks or material leaching from the concrete structures), the staff does not have sufficient information to conclude that the proposed LRA AMP, "Structures Monitoring," will be adequate to manage the effects of aging during the period of extended operation.

Requests:

1. State what actions, if any, have been taken to determine the composition of the material (white deposits). State whether an evaluation has been performed to determine the source of the material deposits. If so, provide the technical basis for that conclusion.
2. Considering that the groundwater at Byron and Braidwood is aggressive, state what actions, if any, have been taken to evaluate the condition of the concrete in these below-grade structures.

Exelon Response:

The response below consists of three sections. The first section will discuss the composition of the mineral deposits, source of deposits, and basis for the conclusion to provide the response to *Request 1* of this RAI. The second and third sections provide the response to *Request 2* of this RAI. The second section will discuss the condition of the concrete of the below grade structures. The third section will discuss planned activities to confirm the condition of the below grade concrete structures.

1. Composition of Deposits

The mineral deposits in the auxiliary feedwater tunnels, main steam tunnels, and the tendon tunnels at Byron and Braidwood have not been analyzed for chemical composition, but activities to determine the chemical composition are planned and will be discussed below. Although the composition of the mineral deposits has not been analyzed, inspection and evaluation of the concrete as described below has determined that the source of the mineral deposits is not the concrete and chemical attack or leaching is not occurring.

Source of Deposits

Evaluations have concluded that the source, of the mineral deposits in the auxiliary feedwater tunnels, main steam tunnels, and the tendon tunnels at Byron and Braidwood, is not from the concrete. The source has been attributed to the evaporation of water in-leakage that has passed through the backfill material as discussed in detail below.

At Byron in 1996, an evaluation was conducted by the site with the assistance of a consultant with concrete expertise to assess the conditions observed. The investigation included a review of drawings, and walkdowns of the auxiliary feedwater tunnels, main steam tunnels, and the tendon tunnels. Portions of the auxiliary feedwater tunnels, main steam tunnels, and the tendon tunnels have experienced water in-leakage at inactive shrinkage cracks and construction joints since original construction. The water in-leakage at these specific locations has been attributed to surface water runoff that collects and is trapped in a contained area between the following structures: the main steam and auxiliary feedwater tunnels and the containment structure on the sides, and the bedrock foundation at the bottom. This contained area was backfilled with a crushed rock material during plant construction. The backfill material is more specifically described as a dolomite, which is calcium magnesium carbonate $CaMg(CO_3)_2$, and not a limestone, which is calcium carbonate $CaCO_3$. The term dolomite is consistent with the UFSAR Byron Sections 2.5.1 and 2.5.4.5.1.4, and UFSAR Byron Figures 2.5-59, 2.5-61 sheets 1 to 6, and 2.5-62. In addition, dissolved carbonate minerals have been measured in the groundwater as documented in UFSAR Byron Tables 2.4-23 and 2.5-7. Other portions of these tunnel structures (not adjacent to the contained area) display much less indication of in-leakage as evidenced by the minimal amount of mineral deposits. Corrective action taken in 1997 covered the ground surface above the contained area with pavement and substantially reduced water in-leakage. Although the groundwater has been characterized as aggressive based on a few of the monitoring wells being high in chlorides, most likely due to salting of roads and parking lots in the vicinity of the wells during the winter months, the groundwater is not aggressive with regards to pH and sulfates. Groundwater considered aggressive due to low pH or high sulfates could potentially result in chemical attack or leaching of the concrete. In 2013, a water sample taken from the tendon tunnel at Byron was analyzed, which determined the water to be non-aggressive (pH > 5.5, chlorides < 500 ppm, sulfates <1500 ppm). As a result, it is reasonable to conclude that the source of the mineral deposits is not the result of chemical attack or leaching of the concrete. The condition of the concrete described below also demonstrates that the mineral deposits are not from the concrete, as the concrete does not exhibit signs of degradation such as weakening or softening of the concrete. Therefore, the source of the mineral deposits in these specific areas has been attributed to residual material resulting from the evaporation of the water in-leakage that has passed through the backfill material.

At Braidwood, no specific evaluation or investigation as to the source of the mineral deposits has been conducted. The quantity of mineral deposits observed at Braidwood is much less than the deposits observed at Byron, most likely due to the sand backfill material used at Braidwood, as described in UFSAR Braidwood section 2.5.4.5.2.2, as opposed to the crushed dolomite material that was used at Byron during plant construction.

2. Condition of Concrete

Although the groundwater has been characterized as aggressive, evaluation of the accessible below grade concrete during routine and ongoing visual and hammer sounding examinations performed at Byron and Braidwood have not revealed any degradation of concrete due leaching or chemical attack. As discussed above, the groundwater at Byron and Braidwood is not aggressive with respect to pH and sulfate values, therefore concrete degradation due to chemical attack or leaching is not expected to occur. The concrete is being monitored, managed, and maintained by the Structures Monitoring (B.2.1.34) aging management program. Concrete at crack locations has been determined to be structurally sound. Some shallow patches, installed for cosmetic reasons, have degraded but the continuing concrete inspections have not detected any concrete degradation beyond the original superficial degradation that existed prior to the shallow patches. Any adverse conditions observed have been documented and reported in the corrective action program for evaluation and resolution. The evaluations have resulted in varying degrees of actions taken, such as no action needed, repair of an area to prevent additional or further degradation, additional examination for further evaluation, and more frequent monitoring. The evaluations have concluded there is no evidence of structural degradation (i.e., no significant cracking, deflection, weakened or softened concrete) of the concrete at these below grade structures that would challenge or impact the integrity of the structures.

In addition, to further support the above conclusion that groundwater is not causing structural concrete degradation, inaccessible below grade concrete exposed during an excavation was examined and found to be in good condition during an opportunistic examination at Byron. This examination is described in LRA Section B.2.1.34, in the fourth operating experience example for Byron. Inaccessible below grade concrete that is exposed during an excavation, allows for close examination of the surfaces that are directly exposed to groundwater as opposed to the inside surfaces of the tunnel structures.

Lastly, there is no evidence of concrete degradation due to alkali-silica reaction (ASR). As discussed in LRA Section B.2.1.35, in the first operating experience example for Byron, extensive examination and concrete testing has been conducted on the essential service water cooling tower at Byron. A total of fifteen cores and two concrete spall samples were examined. Visual examinations were conducted on all seventeen samples. Petrographic examinations were conducted and no ASR damage was observed on a micro-scale (thin sections) or macro-scale. The concrete at the essential service water cooling towers at Byron is exposed to a constant flow of water as opposed to the concrete in the tunnel structures which are exposed to infrequent ground water infiltration. Since Byron and Braidwood share common specifications for construction activities, materials, and testing related to concrete, the examinations and conclusion related to ASR susceptibility at the Byron essential service water cooling towers is considered applicable to other structures at both Byron and Braidwood.

In summary, based on the examinations performed to date on the Byron and Braidwood auxiliary feedwater tunnels, main steam tunnels, and tendon tunnels, and other related examination activities discussed above, there is evidence of mineral deposits, but there is no evidence of concrete degradation as a result of chemical attack or leaching. In addition, there is no evidence of concrete degradation due to ASR. The chemical composition of the mineral deposits is not known, but activities are planned to determine the chemical composition, as described below in Enhancement 16 to the Structures Monitoring (B.2.1.34) aging management program.

3. Planned Confirmation Activities

Confirmation that the mineral deposits observed are not an indication of chemical attack or leaching and confirmation that the underlying concrete is in good condition, will be achieved by a series of activities that will be documented as an enhancement to the Structures Monitoring (B.2.1.34) aging management program as shown below.

LRA Sections A.2.1.34 and B.2.1.34, and LRA Table A.5, Item 34 are revised to add Enhancement 16 as shown below:

16. At each site, perform one-time sampling activities on below grade, reinforced concrete at specific locations in the tendon tunnels. Select the locations exhibiting significant mineral deposits to serve as leading indicators for potential reinforced concrete degradation as a result of exposure to ground water in-leakage and build-up of mineral deposits. Take corrective actions, if necessary, prior to the period of extended operation. Perform the one-time sampling activities as follows:
    a. Obtain water in-leakage samples, at representative locations with mineral deposits due to water in-leakage, and analyze for pH, chlorides, sulfates, minerals, and iron content.
    b. Obtain representative mineral deposit samples and analyze for chemical composition.
    c. Remove three concrete core samples.
        i. Test two of the concrete core samples for compressive strength and perform petrographic examination of the core samples. Select representative locations for the concrete core samples that include one with significant mineral deposits and another at a location with no mineral deposits for comparative purposes.
        ii. Drill an additional core at a crack with significant mineral deposits and subject the core to petrographic examination.
    d. Expose and examine reinforcing steel at two locations, with water in-leakage, cracks, and significant mineral deposits.
    e. Collectively evaluate the results from the water in-leakage analysis, the chemical composition of the mineral deposits, examination of the exposed reinforcing steel, and the core sample testing to confirm there is no significant degradation to the reinforced concrete material properties and to determine if additional corrective actions are necessary. Additional corrective actions may include, but are not limited to, an extent of condition review for other potentially impacted

structures, more frequent examinations, and additional sampling and analysis, as appropriate.

Conclusion

Routine examination of the concrete in the auxiliary feedwater tunnel, main steam tunnel, and the tendon tunnel below grade structures by the Structures Monitoring (B.2.1.34) aging management program, together with the enhancements to the Structures Monitoring (B.2.1.34) aging management program, will ensure that any adverse changes to current conditions will be identified, documented in the corrective action program, and assessed for any potential impact on these and other structures, including inaccessible areas prior to the period of extended operation.

Based on the above, the Structures Monitoring (B.2.1.34) aging management program will adequately manage the effects of aging of these below-grade structures during the period of extended operation.

As a result of RAI B.2.1.34-1, LRA Sections A.2.1.34 and B.2.1.34 are revised as shown in Enclosure B. The Byron and Braidwood LRA Table A.5, Item 34, is also revised to add Enhancement 16 as shown in Enclosure C.

RAI B.2.1.30-1

Applicability:

Byron and Braidwood

Background:

LRA Section B.2.1.30 states that the ASME Section XI, Subsection IWL AMP is an existing program that, following enhancements, will be consistent with the GALL Report AMP XI.S2, "ASME Section XI, Subsection IWL." During its onsite audit at both Byron and Braidwood, the staff reviewed operating experience regarding suspected areas of degradation in the primary containment tendon access gallery tunnel ceilings. The staff noted that, in June 2006 while performing visual examinations of Braidwood's tunnel ceilings concrete surfaces, 11 locations in Unit 1 and 14 locations in Unit 2 were identified as suspect areas with degradation. The suspected areas were covered in white deposits and rust. In addition, during the 2006 20^{th} ASME Section XI, Subsection IWL, concrete examinations at Braidwood Units 1 and 2, degradation was found in the tendon tunnel ceilings near seven vertical tendon anchorage cans. The degradation was within a previously placed patch that extended from the outer wall to the inner wall in the tendon tunnel and consisted of a combination of the following: wet stalactites, surface concrete cracks exceeding .04", heavy accumulation of minerals, corrosion staining, moisture "wetting," accumulation of efflorescence in localized areas, "minor" cracking, and "hollow" sound emitted from the area when tapped with a hammer. In 2012, while performing augmented examination of suspect areas identified during the 2011 25^{th} year ASME IWL examinations, the following conditions were found at Braidwood Unit 2 tendon tunnel ceilings near six additional vertical tendon anchorage cans: buildup of minerals, efflorescence with evidence of moisture, 8" and 5" long stalactites, and surface corrosion on embedded plates.

During the onsite audits at both Byron and Braidwood, the staff performed walkdowns of the tendon access gallery tunnels to observe the overall condition of the area. The staff observed white deposits or efflorescence, stalactites, surface corrosion on embedded plates, and surface cracks in the tunnel ceilings near some of the vertical tendon anchorage cans.

The staff noted that the conditions of concrete degradation at the tendon gallery tunnel ceilings are present at both sites. In addition, based on its review of operating experience, the staff noted that the groundwater at both Byron and Braidwood is considered to be an aggressive environment due to high chloride levels (i.e., > 500 ppm).

Issue:

Per 10 CFR 54.21(a)(3), the applicant is required to demonstrate that the effects of aging will be adequately managed so that the intended function will be maintained consistent with the current licensing basis for the period of extended operation. The staff is concerned that some below-grade areas of the concrete containment are exposed to aggressive groundwater, which may be causing chemical attack and leaching of the concrete. It is not clear whether an evaluation has been performed to assess this condition per the requirements of the IWL Code. The staff needs additional information to determine whether the LRA ASME Section XI, Subsection IWL AMP will be adequate to manage the effects of aging during the period of operation (PEO).

Request:

State whether the concrete in the tunnel ceiling is subject to chemical attack or leaching, and provide results of any evaluation conducted or planned to determine the composition of the material (e.g., mineral build-up, white efflorescence) and to evaluate the condition of the concrete at the tendon gallery tunnel ceilings.

Exelon Response:

The below discussion is presented in four sections. The first section will describe the reason the tendon tunnel ceiling concrete is not subject to chemical attack or leaching. The second section will discuss the evaluation of the mineral deposits and planned analysis to determine the chemical composition of the mineral deposits. The third section will provide the results of evaluations and inspections conducted to determine the condition of the concrete at the tendon tunnel ceiling. The fourth section will discuss planned confirmation activities to determine the chemical composition of the mineral deposits and the condition of the concrete at the tendon tunnel ceiling.

Concrete Not Subject to Chemical Attack or Leaching

Concrete degradation due to chemical attack or leaching has not been observed at the tendon tunnel ceiling concrete at Byron and Braidwood. Chemical attack or leaching is not expected, because the groundwater is not aggressive with respect to pH or sulfates. Groundwater considered aggressive due to low pH or high sulfates could potentially result in chemical attack or leaching of the concrete. The groundwater at Byron and Braidwood has been generally characterized as aggressive based on some of the monitoring wells being high in chlorides (i.e., >500ppm), most likely due to salting of roads and parking lots near the wells during the winter months, but the groundwater is not aggressive with regards to pH or sulfates (i.e., pH > 5.5, sulfates <1500 ppm). In 2013, a water in-leakage sample taken from the Byron tendon tunnel was analyzed. The in-leakage water at Byron was found to be non-aggressive (pH > 5.5, chlorides < 500 ppm, sulfates <1500 ppm). At Braidwood, a water in-leakage sample has not yet been taken and analyzed, but is planned as a confirmation activity. Based on the groundwater at both Byron and Braidwood not being aggressive with respect to pH or sulfates, it is reasonable to conclude that chemical attack and leaching is not expected to occur.

Composition of Mineral Deposits

The mineral deposits on the concrete tendon tunnel ceilings at Byron and Braidwood have not been analyzed for chemical composition. However, an evaluation of the source of the mineral deposits was performed at Byron and is discussed in the response to RAI B.2.1.34-1. The evaluation attributes the source of the mineral deposits to residual material resulting from the evaporation of the water in-leakage that has passed through the dolomite (calcium magnesium carbonate) backfill material. At Braidwood, no specific evaluation or investigation as to the source of the mineral deposits has been conducted. The quantity of mineral deposits observed at Braidwood are much less than the deposits observed at Byron, most likely due to the differences in the backfill material used, which is also discussed in the response to RAI B.2.1.34-1. Inspection and evaluation of the concrete as described below has also concluded that the source of the mineral deposits is not the concrete, and chemical attack or leaching is not occurring. Planned confirmation activities will include analysis to determine the chemical composition of the mineral deposits as described below and documented in the response to RAI

B.2.1.34-1 as Enhancement 16 to the Structures Monitoring (B.2.1.34) aging management program.

<u>Evaluations and Condition of Concrete</u>

Evaluations and detailed examinations performed at Byron and Braidwood have concluded there is no evidence of structural concrete degradation at the tendon tunnel ceiling.

ASME Section XI, Subsection IWL Section 2510 provides criteria to perform evaluations of concrete containment surfaces to identify and determine areas as "suspect areas" (areas where there is evidence of conditions indicative of damage or degradation). At Byron and Braidwood, as a part of the development of the ASME Section XI, Subsection IWL program implementing documents, specific evaluations were performed to identify and evaluate potential suspect areas in 2001. The evaluations at Byron and Braidwood identified the bottom grease cans and the accessible surfaces of the concrete base mat in the vicinity of the bottom tendon grease cans as suspect areas, due to the tendon being below grade and susceptible to groundwater intrusion. Suspect areas require a detailed visual examination in addition to a general visual examination per Table IWL-2500-1, every five years, in accordance with IWL-2500. Detailed examinations of these areas in 2001, 2006, and 2011 at both Byron and Braidwood have reported the conditions observed and entered any adverse conditions into the corrective action program. The responsible engineer has evaluated these conditions against IWL-3000 Acceptance Standards.

The detailed examinations revealed conditions such as:

- Previously placed cosmetic superficial patches had cracked or degraded.
- Corrosion stains observed were due to steel exposed on the surface, (e.g., surface mounted conduit, and surface corrosion of embedded plates), and not the result of corrosion of reinforcing steel.
- Surface cracks in the concrete exceeding 0.04" in width at the surface which were investigated were found to be much narrower below the surface.

The evaluation of conditions reported resulted in varying degrees of actions taken such as, no action needed, cosmetic repairs of superficial areas to prevent additional or further degradation, additional detailed examinations after cleanup of mineral deposits for further evaluation, and more frequent monitoring. The examinations and evaluations concluded there is no evidence of structural concrete degradation (i.e., no significant cracking, deflection, weakened or softened concrete, or post tensioning system damage) of the concrete at the tendon tunnel ceilings that would challenge or impact the integrity of the containment structure.

In addition, to further support the above conclusion that groundwater is not causing structural concrete degradation, inaccessible below grade concrete exposed during an excavation was examined and found to be in good condition during an opportunistic examination at Byron. This examination is described in LRA Section B.2.1.34, in the fourth operating experience example for Byron. Inaccessible below grade concrete that is exposed during an excavation, allows for close examination of the surfaces that are directly exposed to groundwater as opposed to the inside surfaces of the tendon tunnel ceilings.

Lastly, there is no evidence of concrete degradation due to alkali-silica reaction (ASR). As discussed in LRA Section B.2.1.35, in the first operating experience example for Byron, extensive examination and concrete testing has been conducted on the essential service water

cooling tower at Byron. A total of fifteen cores and two concrete spall samples were examined. Visual examinations were conducted on all seventeen samples. Petrographic examinations were conducted and no ASR damage was observed on a micro-scale (thin sections) or macro-scale. The concrete at the essential service water cooling towers at Byron is exposed to a constant flow of water as opposed to the concrete in tendon tunnel ceilings which are exposed to infrequent ground water infiltration. Since Byron and Braidwood share common specifications for construction activities, materials, and testing related to concrete, the examinations and conclusion related to ASR susceptibility at Byron essential service water cooling towers is considered applicable to other structures at both Byron and Braidwood.

In summary, based on the ASME Section XI, Subsection IWL program inspections performed to date on the Byron and Braidwood tendon tunnel ceilings, and other related examination activities discussed above, there is evidence of mineral deposits, but there is no evidence of concrete degradation as a result of chemical attack or leaching. In addition, there is no evidence of concrete degradation due to ASR. Chemical analysis has not been performed to determine the chemical composition of the mineral deposits, but activities are planned to determine the chemical composition as described below, and documented in the response to RAI B.2.1.34-1 as Enhancement 16 to the Structures Monitoring (B.2.1.34) aging management program.

Planned Confirmation Activities

The environment (moisture) and mineral deposits due to water in-leakage that exists at the interior side of the outer tendon tunnel wall is a bounding and representative environment with respect to the environment that exists at the tendon tunnel ceilings. The tendon tunnel ceiling is the bottom of the outer edge of the base mat of the containment structure and is twelve (12) feet thick, as shown in UFSAR Figures 3.8-1. The outer tendon tunnel wall is at a lower elevation than the tendon tunnel ceiling and is approximately three (3) feet thick, as shown in UFSAR Figures 3.8-2. This configuration results in a higher head of water pressure and establishes a preferential flow path for water infiltrating the concrete at the tendon tunnels walls. In addition, the tendon tunnel ceiling is post-tensioned with vertical tendons, which close up any shrinkage cracks; therefore the tendon tunnel ceiling is significantly less permeable with respect to water seepage into the concrete than the tendon tunnel walls, which are not post-tensioned. Since the mineral deposits and conditions observed at the tendon tunnel ceiling is considered bounded by the mineral deposits and conditions observed on the interior side of the outer tendon tunnel walls, confirmation activities to demonstrate the condition of the concrete of the tendon tunnel walls can also be used to confirm the condition of the concrete of the tendon tunnel ceiling. The tendon tunnel walls are monitored under the Structures Monitoring (B.2.1.34) aging management program every five years.

Confirmation that the mineral deposits observed at the tendon tunnel ceiling are not an indication of chemical attack or leaching and confirmation that the underlying concrete is in good condition, will be achieved by a series of activities that are documented as Enhancement 16 to the Structures Monitoring (B.2.1.34) aging management program as discussed in RAI B.2.1.34-1 and are summarized below.

The enhancement to the Structures Monitoring (B.2.1.34) aging management program will include the determination of bounding locations (locations with evidence of water in-leakage and larger buildup of mineral deposits) at Byron and Braidwood sites. Water in-leakage samples will be taken in the tendon tunnels at each site and analyzed for pH, chlorides, sulfates, minerals,

and iron content. Mineral deposit samples will be taken at each site and analyzed for chemical composition. Core samples will be taken at each site and tested for compressive strength and be subjected to petrographic examination. Reinforcing steel will be exposed and examined for corrosion. The results, from the water in-leakage analysis, the chemical composition of the mineral deposits, the examination of reinforcing steel, and the core sample testing will be collectively reviewed and evaluated at each site. Any adverse findings will be entered into the corrective action program to determine appropriate corrective actions including, but not limited to, an extent of condition review for other potentially impacted structures, more frequent inspections, additional sampling and analysis of water in-leakage for minerals and iron content, and additional core samples, as appropriate. The enhancement will be implemented prior to the period of extended operation.

Conclusion

Ongoing inspections of the concrete in the tendon tunnels, both by the Structures Monitoring (B.2.1.34) aging management program (walls and floor) and the ASME Section XI, Subsection IWL (B.2.1.30) aging management program (ceiling), together with the enhancement to the Structures Monitoring (B.2.1.34) aging management program summarized above and documented in the response to RAI B.2.1.34-1, will ensure that any adverse changes to current conditions will be identified, documented in the corrective action program, and assessed for any potential impact on structures and areas, including inaccessible areas prior to the period of extended operation.

Based on the above, the ASME Section XI, Subsection IWL (B.2.1.30) aging management program will adequately manage the effects of aging of the tendon tunnel ceilings during the period of extended operation.

RAI B.2.1.30-2

Applicability: Braidwood

Background:

LRA Section B.2.1.30 states that the ASME Section XI, Subsection IWL AMP is an existing program that, following enhancements, will be consistent with the GALL Report AMP XI.S2, "ASME Section XI, Subsection IWL." During its review of Braidwood operating experience, the staff noted that ASME Section XI, Subsection IWL, inspections have revealed that the sealant and cover are significantly degraded or missing at some of the drain assemblies in the dome area of the containment. Plant operating experience has documented that there is separation, chips, and loose concrete at some of the dome drains; accumulation of white deposits or efflorescence on concrete surfaces near all of the drains; and accumulation of water at the dome drains. The staff noted that the applicant performed a detailed visual examination of the suspected areas of concrete deterioration in accordance with Subsection IWL-3210 of the ASME Code. During the detailed visual examinations, additional signs of deterioration were found on suspected areas of concrete in the form of "minor" spalls near the drains and cracks extending from all six dome drain penetrations (one reported as being more than 6" long and .8" wide at the concrete surface), efflorescence within the cracks, and corrosion staining.

Issue:

10 CFR 54.21(a)(3) requires that the applicant demonstrate that the effects of aging will be adequately managed so that the intended function will be maintained consistent with the current licensing basis for the period of extended operation. The staff noted that issues with degradation of the dome drainage system and suspected areas of concrete deterioration have been identified during previous ASME Section XI, Subsection IWL examinations at Braidwood. The staff is concerned that the conditions observed by the applicant near the dome drains (accumulation of white deposits, water accumulation, spalling, cracks, and corrosion staining) may be indicative of, or may result in, degradation. The water accumulated may leak through the cracks and reach the concrete rebar which can result in degradation of the rebar. The staff needs additional information regarding the condition of concrete suspected areas of degradation and methods of evaluation to conclude that the LRA ASME Section XI, Subsection IWL AMP will be adequate to manage the effects of aging during the period of extended operation.

Request:

Regarding the reported conditions of the containment concrete at the dome drainage system, state whether further actions have been taken or are needed per appropriate programs such that concrete degradation can be evaluated and appropriate mitigating actions are implemented to prevent loss of intended function during the period of extended operation. Also, provide a summary of actions that have been taken to date to correct the degraded condition of the dome drainage system such that water does not accumulate in the suspected areas of concrete degradation near the dome drains.

Exelon Response:

Summary

Regarding the reported conditions of containment concrete for the dome drainage system involving this request for information with the dome drain inlets and where the dome drain line exits the concrete, the corrective actions have been completed to restore the containment dome drain inlets to the proper configuration. Follow-up examinations have been performed, which have verified the effectiveness of the repairs. Periodic monitoring actions will continue to be performed as part of the ASME Section XI, Subsection IWL (B.2.1.30) and Structures Monitoring (B.2.1.34) aging management programs. The concrete cracking at the exit of the drain piping has been determined to be structurally insignificant and therefore acceptable in accordance with the IWL (B.2.1.30) aging management program. There are no further actions required to be taken or that are needed in accordance with IWL-3210 at this time. Any future concrete degradation will be evaluated and appropriate mitigating actions will be implemented to prevent loss of the intended function prior to and during the period of extended operation. Enhancement #3 to the IWL (B.2.1.30) aging management program addresses the potential for water ingress into the dome tendons and is addressed under RAI B.2.1.30-3. Below are the details of the reported conditions and corrective actions associated with the dome drain inlets at the top of the containment and the concrete at the drain line exits on the vertical edge of the containment cylinder wall, which are summarized above.

Dome Drain Inlets at the Top of Containment

The degradation of the containment dome drains was initially identified on Braidwood Units 1 and 2 and documented in the corrective action program in August 2011 as a follow-up to the IWL general visual examination findings. The dome drain inlets had been examined in 2006 and no degradation was identified during that examination. The dome drains consist of an inlet cover over the drain inlet at the intersection between the containment dome and the curb that supports the inner radius of the dome walkway enclosure. These findings in 2011 documented the degradation of the drain inlets. The missing and degraded sealant caused the leakage of water into the annulus between the drain pipe sleeve (8-inch) and drain piping (6-inch). Additionally, this sealant (caulking) around the drain inlet covers was dried out or missing due to extended exposure to the weather. These degraded conditions were repaired to their original configuration by January 2012. As part of the corrective action program, repairs to the dome drains have been completed to prevent the accumulation of water on the containment dome. Subsequent examinations of both units containment dome drainage systems were performed in August 2012 and August 2013 with no additional degradation identified in these areas to ensure that the corrective actions taken in 2011 were effective. There are established periodic preventive maintenance tasks to inspect the containment dome drains every five years as part of the Structures Monitoring (B.2.1.34) aging management program. These inspections will ensure that the material condition of the containment dome drains will be maintained.

The concrete at the top of the containment dome that forms the inlet for the containment dome drains is a part of the curb that supports the inner radius of the walkway enclosure on top of the dome, which is described in LRA section 2.4.4 as part of the Containment exterior structural features. The concrete curb and drain inlet is not part of the containment pressure boundary managed as part of the ASME Section XI, Subsection IWL (B.2.1.30) aging management program. The concrete curb and drain inlet are managed under the Structures Monitoring (B.2.1.34) aging management program.

Concrete at the Containment Dome Drain Line Exits on the Vertical Cylinder Wall

During the October 2011 Braidwood Unit 1 and Unit 2 surveillance as part of the 25th Year Post Tensioning Surveillances and augmented inspections, accumulations of calcium deposits (efflorescence) were identified on the containment concrete surfaces where all six drain lines exit the concrete on top of the dome at the vertical edge of the concrete containment cylinder wall. Similar conditions were identified during the previous examination in 2006. All six drain pipes were found to have some cracking beneath the piping penetrations. These cracks emanate from the bottom of the drain pipe sleeves. After the efflorescence was removed, detailed visual examinations were performed and the maximum measured crack width on Unit 1 near dome tendon D2-23 and on Unit 2 near dome tendons D4-23 and D4-24 was 0.080 inches wide at the surface, which narrowed to 0.015 inches wide at a depth of no more than 0.125 inches. The cracking had been documented in the corrective action program with a typographical error, where it was initially reported that the crack varied from 0.80 inches to 0.15 inches in width. The efflorescence has been attributed to the leakage bypassing the containment dome drain piping and the dome drain piping sleeve. There is no impact to the Containment Structure as a result of the cracks below the drain piping penetrations since the cracks have been consistent between 2006 and 2011, and due to the absence of the following evidence: reinforcing steel corrosion; spalls that would indicate corrosion of the concrete rebar; or shifting of concrete due to cracking. In addition, even though isolated vertical concrete cracks have been found, the intersecting cracks associated with cracking due to expansion from reaction with aggregates have not been identified near the containment dome drain piping. The concrete cracking near the drain piping will continue to be monitored by the ASME Section XI, Subsection IWL (B.2.1.30) aging management program. Subsequent examinations of the concrete cracks around the drainage pipes were performed in August 2012 and August 2013 with no additional degradation identified in these areas.

In conclusion, there is no exposed reinforcing steel or evidence of corrosion at the dome drains or where the drain pipes exit the wall. The concrete in these areas is sound and there is no indication of reinforcing steel corrosion, spalling of concrete due to reinforcing steel corrosion, or shifting of concrete due to cracking. The conditions do not affect the structural integrity of the containment and do not indicate age-related degradation of the structural concrete containment.

The LRA Section 2.4.4, Containment Structure, is revised to provide a further explanation regarding the exterior structural features of the containment, as shown in Enclosure B.

RAI B.2.1.30-3

Applicability:

Braidwood

Background:

LRA Section B.2.1.30 states that the ASME Section XI, Subsection IWL AMP is an existing program that, following enhancements, will be consistent with the GALL Report AMP XI.S2, "ASME Section XI, Subsection IWL." LRA Section B.2.1.30 states that "free-water has been found in 3-8% of the tendon inspections at Braidwood Unit 2…the presence of free water has been consistently detected in specific horizontal, vertical, and dome tendons, and this type of condition has also been detected [at] Braidwood Unit 1." The LRA further states that, since Braidwood construction, free water has been found in a "few, specific horizontal and vertical tendon anchorages located below grade." The LRA also states that the water in the dome tendons is due to the degraded dome drainage system and that the water found at vertical tendons and below-grade horizontal tendons is due to the high water table, which is about 20 to 25 feet higher than the bottom of the containment.

LRA Section B.2.1.30 states that to address the presence of water in the tendon sheaths, the applicant has performed augmented inspections on additional tendons beyond those selected for the ASME Section XI, Subsection IWL, Program. These augmented inspections are performed every five years in conjunction with the ASME Section XI, Subsection IWL examinations. The LRA also states that due to the history of water found in containment tendons, the applicant included Enhancements 2 and 3 to the ASME Section XI, Subsection IWL AMP.

Enhancement 2 states:

> A one-time inspection of one (1) vertical and one (1) horizontal tendon on each unit will be performed prior to the period of extended operation. The inspection will consist of visually examining one (1) wire from each of the two (2) types of tendons at a worst-case location based on evidence of free water, grease discoloration, and grease chemistry results. This location will serve as a leading indicator for potential degradation or tendon surface corrosion (Braidwood only).

Enhancement 3 states:

> In order to monitor for tendon exposure to free water and moisture and manage any potential adverse effects, a periodic tendon water monitoring and grease sampling program will be implemented (Braidwood only). The program will consist of:
>
> (a) A baseline inspection of tendon grease caps at the bottom of all vertical and dome tendons, as well as all below-grade horizontal tendons, prior to the period of extended operation. The baseline inspection will check for evidence of free water and grease discoloration, with further actions taken based on the condition of the grease.

(b) A follow-up tendon grease cap inspection of all vertical and dome tendons, as well as all below-grade horizontal tendons, will be performed within 10 years of the initial inspection, using the same approach as the baseline inspection.
(c) For those tendons where free water, moisture, and grease did not meet acceptance criteria during the two (2) previous inspections, periodic monitoring of grease chemistry and moisture, free water, and grease discoloration will be performed on a frequency not to exceed 10 years.

Corrective actions will be taken as necessary to ensure that the tendon grease meets ASME Section XI, Subsection IWL requirements.

Issue:

The GALL Report states that "the conditions and operating experience at the plant must be bound by the conditions and operating experience for which the GALL program was evaluated, otherwise it is incumbent on the applicant to augment the GALL program as appropriate to address the additional aging effects." The GALL Report also states that "[o]perating experience involving the AMP, including past corrective actions resulting in program enhancements or additional programs, should provide objective evidence to support a determination that the effects of aging will be adequately managed so that the structure and component intended functions will be maintained during the period of extended operation." The staff noted that the applicant has augmented and will enhance (Enhancements 2 and 3) its IWL AMP to address its plant-specific operating experience regarding the historical exposure of tendons to free water at Braidwood. However, the staff needs additional information regarding how the augmented inspections and enhancements will adequately manage the effects of aging during the period of extended operation. The staff has the following concerns:

- For the augmented inspections of additional tendons, performed every five years in conjunction with the ASME Section XI, Subsection IWL examinations, it is unclear how the locations for additional tendon inspections will be identified.
- Enhancement 2 proposes a one-time inspection of one horizontal and vertical tendon prior to the period of extended operation. It is not clear what the acceptance criteria will be for the one-time inspection of the corrosion protection medium and tendon wires and what further actions will be taken if the acceptance criteria are not met. Additionally, the enhancement does not include inspection of dome tendons, and the basis for this exclusion is not clear.
- Enhancement 3 states that a follow-up inspection will be performed within 10 years after the first baseline inspection. The enhancement also states that tendons that do not meet the acceptance criteria during the two previous inspections will be subject to periodic monitoring at a frequency not to exceed 10 years. The staff is concerned that tendons that meet the acceptance criteria during the baseline inspection but do not meet the acceptance criteria in the follow-up inspection will not be subject to periodic monitoring. For sites with multiple plants, IWL-2421(b) states that when the conditions on IWL-2421(a) are met, the examinations required by IWL-2500 can be performed at a 10-year frequency instead of every five years. A 10-year frequency is the maximum frequency (less conservative approach) allowed by the IWL Code for a site with multiple plants. It is unclear as to how a frequency of examinations not to exceed 10 years will be adequate to address the additional aging effects at Braidwood.

<u>Request</u>:

1. Describe how the locations for augmented inspections of additional tendons will be identified.
2. Regarding Enhancement 2, state (1) the acceptance criteria for the one-time inspections, (2) what actions will be taken if the acceptance criteria are not met, and (3) the justification for not performing a one-time inspection of the dome tendons
3. Regarding Enhancement 3, state (1) what actions will be taken for those tendons where the corrosion protection medium meets the acceptance criteria during the baseline inspection but are found not acceptable during the follow-up inspection, and (2) how the proposed frequency of inspections (not to exceed 10 years) will ensure that possible age-related degradation due to water inleakage to the tendons will be detected in a timely manner and managed such that the tendons will continue to perform their intended functions during the PEO.

<u>Exelon Response</u>:

1. The locations of augmented inspections of tendons performed every five (5) years, beyond those selected for ASME Section XI, Subsection IWL, as described in LRA Section B.2.1.30, have previously been identified by the Responsible Engineer. These augmented tendon locations have been associated with tendons that have previously been examined and found to exhibit significant quantities (e.g., more than eight ounces) of free water, as well as other tendons of potential susceptibility and interest, as determined by the Responsible Engineer. Augmented inspections of other tendons of interest consist of those nearby and adjacent to ones which have previously exhibited free water. These augmented inspections, performed every five (5) years, will continue until implementation of Enhancement 3.

   Upon implementation of Enhancement 3, augmented inspections of tendons will include an initial baseline inspection of the bottom of all vertical and dome tendons, as well as all below-grade horizontal tendons, prior to the period of extended operation. A follow-up inspection of all vertical and dome tendons, as well as all below-grade horizontal tendons, will also be performed within ten (10) years of the initial baseline inspection. Following this second inspection, additional periodic augmented inspections and monitoring will be conducted for those tendons where free water, moisture, and grease did not meet acceptance criteria during the two (2) previous inspections. Additional information on the frequency of these periodic augmented inspections and monitoring is provided below in the response to *Request* 3.

2. The one-time inspections identified in Enhancement 2 to the ASME Section XI, Subsection IWL, (B.2.1.30) aging management program will consist of visual inspections of one wire taken from a horizontal tendon and one wire taken from a vertical tendon. The visual inspection of these wires will be performed in accordance with existing station procedures used for inspections consistent with IWL-2523.2. The acceptance criteria will consist of each wire being free of any active corrosion, including general and pitting corrosion.

   The intent of these one-time inspections is to verify the effectiveness of the grease in providing corrosion protection to the tendon wires, especially for tendons which have historically experienced greater quantities of free water and moisture. In the event that the acceptance criteria are not met and corrosion is identified, the condition would be entered into the corrective action program. The condition would be evaluated to characterize the

corrosion, determine the cause of the corrosion, the location, depth, extent of the condition, and applicability of the condition to other wires that comprise that tendon. Corrective actions may include activities such as grease analysis, replacement of grease within the tendon duct, additional wire inspections from the same tendon, evaluation of the tendon capacity, potential replacement of the tendon, and augmented inspections and grease sampling of other leading indicator tendons, based, in part, on previous evidence of free water, observed grease leakage, grease discoloration, and grease chemistry results. Specific corrective actions would depend upon the cause, extent of condition, and grease properties. These corrective actions are consistent with those actions which would be evaluated during periodic required IWL examinations.

The one-time inspections specified in Enhancement 2 to the ASME Section XI, Subsection IWL (B.2.1.30) aging management program were not specified for the dome tendons due to relatively few instances of significant free water being found in the dome tendons, in comparison to the vertical and below-grade horizontal tendons. All three tendon groups (vertical, horizontal, dome) are of the same design with respect to configuration, tendon sheathing, and protective grease. Since the below-grade horizontal tendons and the bottom ends of the vertical tendons have historically shown greater exposure to free water due to their location at or below the ground-water table, the environmental conditions to which these tendons are exposed are considered to bound that of the dome tendons. In addition, repairs to the containment roof drain system were recently completed in 2011 and 2012 for both units, which are expected to reduce the potential of future water intrusion into the dome tendon sheaths. Therefore, selection of wires from a worst-case below-grade horizontal and select vertical tendon will serve as leading indicators for potential degradation or tendon surface corrosion.

In order to address the limited number of instances in which significant free water has been found in the dome tendons, however, periodic tendon water monitoring and grease sampling activities outlined in Enhancement 3 to the ASME Section XI, Subsection IWL (B.2.1.30) program includes the dome tendons. Therefore, potential free water in the dome tendon sheaths will be managed to ensure that the tendons continue to perform their intended function through the period of extended operation.

3. Regarding Enhancement 3 to the ASME Section XI, Subsection IWL (B.2.1.30) aging management program, any tendons which meet the acceptance criteria during the initial baseline examination of all vertical, dome, and below-grade horizontal tendons, but fail to meet the acceptance criteria during the subsequent examination ten (10) years later, will be subject to additional periodic monitoring. Tendons which exhibit significant quantities of free water during periodic monitoring will be inspected more often, with the timing of follow-up inspections increased until a frequency is achieved which no longer results in significant amounts of free water observed during successive inspections. Tendon water inspection and draining frequencies may vary from annual to every ten (10) years, depending upon grease chemistry and moisture parameters meeting IWL acceptance criteria. By continuing to increase the frequency of inspection for, and removal of, free water until significant amounts are no longer observed, the condition of the grease will be maintained and continue to provide corrosion protection to the tendon wires, thereby, ensuring that the intended function of the containment tendons is maintained during the period of extended operation.

The maximum ten (10) year periodic frequency allowed in part ‘c’ of Enhancement 3 is meant to address any tendons which exhibit evidence of free water but the quantity is observed to be insignificant, with no observable grease discoloration, and given that the tendon wasn’t inspected for at least ten (10) years prior. Tendons, which meet these criteria, are not considered as susceptible to potential degradation due to the historical performance of the tendon grease, which has been proven capable of providing adequate corrosion protection. In instances such as these, since it previously took at least ten (10) years to accumulate an insignificant quantity of free water with no anticipated detrimental effects on the tendon and wires, a ten (10) year subsequent re-inspection is sufficient. More frequent follow-up inspections will be performed for tendons which exhibit insignificant quantities of free water, but were inspected within the ten (10) years prior. Any tendons which exhibit significant quantities of free water or grease discoloration will also be inspected more frequently. In all cases, the frequency of inspections for water in individual tendons will be adjusted to be commensurate with the severity of the conditions found during each subsequent examination.

Based on past examination results, the high quality grease, which is used as a corrosion protection medium to protect the tendons and is tolerant of excessive quantities of moisture, has been adequate to prevent corrosion of the tendons exposed to water. All of the examination evidence to-date, including the current augmented examinations on additional tendons beyond those selected for ASME Section XI, Subsection IWL scheduling requirements, reveals that the tendons are being adequately managed, even with the exposure to water. Therefore, the ASME Section XI, Subsection IWL (B.2.1.30) aging management program, including the proposed enhancements related to monitoring and maintenance of the tendons and grease condition, will manage the condition of the tendons such that they will continue to perform their intended functions through the period of extended operation.

RAI B.2.1.30-4

Applicability:

Braidwood

Background:

LRA Section B.2.1.30 states that the ASME Section XI, Subsection IWL AMP is an existing program that, following enhancements, will be consistent with the GALL Report AMP XI.S2, "ASME Section XI, Subsection IWL." The GALL Report AMP XI.S2 states that "IWL-2510 specifies that concrete surfaces are examined for conditions indicative of degradation, such as those defined in American Concrete Institute (ACI) 201.1R and ACI 349.3R." ACI 201.1R, "Guide for Conducting a Visual Inspection of Concrete Surfaces," and ACI 349.3R, "Evaluation of Existing Nuclear Safety-Related Concrete Structures," identify rust staining as a condition that may be indicative of concrete degradation. The GALL Report also states that "visual examination methods and testing would identify the aging effects of accessible concrete components."

During the Byron and Braidwood onsite AMP audits, the staff performed a walkdown to observe the exterior surfaces of Braidwood Units 1 and 2 containments and noted a vertical line of rust staining on the south face of the Unit 2 concrete containment.

Issue:

As described in ACI 349.3R, rust staining is a condition that can be indicative of active corrosion of iron based material that is taking place internally in the concrete containment or externally on the surface of the structure. Based on the review of the Braidwood operating experience, on-site available documentation, and interviews with the applicant, it's not clear (1) what is the cause of the rust staining, (2) whether the noted condition is indicative of age related degradation, and (3) how the condition is being addressed (e.g., through visual examination methods and testing consistent with the ASME Section XI, Subsection IWL AMP).

Request:

1. Identify the cause of the vertical line(s) of rust stains.
2. State whether there are aging effects associated with the rust stains.
3. State whether the rust stains have been evaluated and will be monitored consistent with IWL-2510. Provide a summary of your results and the technical basis for the response.

Exelon Response:

1. The discoloration stains noted on the exterior surface of the southern side of the Braidwood Unit 2 Containment Structure have been caused by construction aids, such as form ties and form nails exposed on the external surface of the containment structure, and excess form release agent. There is no evidence of exposed reinforcing steel in or around the vertical stains. The concrete surrounding the stains is intact with no evidence of age-related degradation such as cracking with outwards displacement or incipient spalls due to rebar corrosion.

2. The discoloration stains are not a result of aging effects associated with systems, structures, or components (SSCs) that perform a license renewal intended function. The stains are a result of loss of material of exposed steel construction aids, such as form ties and form nails. The IWL concrete surface examinations performed in 2001, 2006, and 2011 have included these areas and found the concrete to be intact with no evidence of age-related degradation. Specifically, there are no indications which would suggest the discoloration stains are due to corrosion or degradation of reinforcing steel, such as cracking with outward displacement or incipient spalls due to rebar corrosion. A review of documentation and available photos has revealed no appreciable change in the vertical line of discoloration staining on the south face of the Braidwood Unit 2 concrete containment.

3. The exterior concrete containment surface is examined every five (5) years and evaluated in accordance with IWL-2510. Rust stains are included as an applicable attribute that is identified during the visual examinations. These areas of discoloration are assessed during every IWL five (5) year examination interval and have previously been evaluated as cosmetic with no evidence of structural degradation sufficient to warrant further evaluation or repair. Based on visual inspections, it has been determined that there is no active degradation of SSCs within the scope of license renewal associated with these discoloration stains. These areas will continue to be monitored for any changes every five (5) years, consistent with IWL-2510.

The staining is a superficial, cosmetic imperfection that is due to construction aids, such as form ties and form nails exposed on the external surface of the containment structure, and excess form release agent. There is no evidence of corrosion of reinforcing steel in or around the vertical stains. The vertical stains have been monitored through visual examinations in accordance with ASME Section XI, Subsection IWL. It has been concluded that the vertical stains are not indicative of age-related degradation. Therefore, the condition is being addressed through visual examination methods consistent with the ASME Section XI, Subsection IWL (B.2.1.30) aging management program.

RAI B.2.1.29-1

Applicability:

Byron

Background:

LRA Section B.2.1.29 states that the ASME Section XI, Subsection IWE program is an existing program that, following enhancement, will be consistent with the GALL Report, Revision 2, AMP XI.S1. The "detection of aging effects" program element recommends, in accordance with IWE-1240, that augmented examinations should be performed for containment surface areas subject to degradation. In addition, the GALL Report states that operating experience involving the AMP should provide objective evidence to support a determination that the effects of aging will be adequately managed so that the structure and component intended functions will be maintained during the PEO.

During the audit, the staff performed walkdowns of the Byron main steam and tendon gallery tunnels and observed white material deposits on the concrete walls and tendon gallery tunnel ceilings, indicative of water leakage or seepage through the containment concrete. Through discussions with the applicant, the staff learned that the cracks through which the material appears to be leaching have existed since initial plant construction. The staff noted during its review that on the south side of Byron Unit 1 and north side of Unit 2, the below grade areas between the main steam tunnels and containment structures were in-filled with limestone during the original construction. According to plant operating experience, this area has allowed groundwater infiltration to the below-grade containment concrete. The staff noted that the groundwater at both Byron and Braidwood is considered to be an aggressive environment due to high chloride levels (i.e., >500 ppm).

IWE-1240 states that interior and exterior containment surface areas that are subject to accelerated corrosion, with no or minimal corrosion allowance, require augmented examinations.

Issue:

With the history of aggressive water infiltrating the containment concrete, as evidenced by signs of water intrusion at the tendon gallery ceilings, there is the potential that elevated moisture levels at the outside of the containment concrete could cause moisture to travel through the concrete and come in contact with the carbon steel containment liner. This condition could result in degradation of the containment liner plates caused by accelerated corrosion at exterior surfaces of the containment liner. The applicant has not provided information, based on examination or analysis, on a determination as to whether water has been in contact with the outer surface of the liner or whether there has been any loss of thickness in the carbon steel due to accelerated corrosion in order to ensure the requirements of IWE-1240 are met.

Request:

With regards to the operating experience indicating that water is infiltrating the containment concrete, state whether there has been (or will be) an evaluation in accordance with IWE to determine (1) if the moisture could come into contact with the liner plate and (2) any resulting

loss of material thickness due to corrosion. Describe how the IWE AMP will be able to ensure that the liner is not degraded such that the leak-tight integrity of the carbon steel is maintained through the PEO.

Exelon Response:

A specific evaluation was conducted in accordance with requirements of IWE-1240 “Surface Areas Requiring Augmented Examination”, to identify those areas to be considered for potential augmented inspections during the development of the containment inservice inspection implementation documents in 2001. The following information was considered in making the determinations: material, location, environment, operational conditions, industry concerns, plant examination data, plant unique experience, and other applicable factors such as design loads. There has been no indication of accelerated general corrosion and aging, or potential for accelerated general corrosion and aging of the exterior surfaces of the Byron containment shell liner plates. Therefore, the exterior of the containment liner plates was not included as a potential augmented inspection area. Discussion to support this determination is provided below.

Background Information

Portions of the tendon tunnel that are adjacent to the main steam and auxiliary feedwater tunnel structure have experienced water in-leakage at inactive shrinkage cracks and construction joints since original construction. The water in-leakage at the tendon tunnel has been attributed to surface water runoff that collects and is trapped in a contained area between the following structures: the main steam and auxiliary feedwater tunnels and the containment structure on the sides, and the bedrock foundation at the bottom. Corrective action that was taken in 1997 covered the ground surface above the contained area with pavement. This action substantially reduced water in-leakage into the tendon tunnel. Other portions of the tendon tunnel (not adjacent to the main steam and auxiliary feedwater tunnel) display much less indication of in-leakage as evidenced by the minimal amount of mineral deposits. The heavier mineral deposits in the tendon tunnel adjacent to the main steam and auxiliary feedwater tunnel have been attributed to the backfill material and water in-leakage from the water trapped in the contained area. The backfill material is more specifically described as a dolomite, which is calcium magnesium carbonate $CaMg(CO_3)_2$, and not a limestone, which is calcium carbonate $CaCO_3$. The term dolomite is consistent with the UFSAR Byron Sections 2.5.1 and 2.5.4.5.1.4, and UFSAR Byron Figures 2.5-59, 2.5-61 sheets 1 to 6, and 2.5-62.

Discussion

The exterior surface of the containment shell liner is inaccessible, therefore the conditions present cannot be directly observed. The first section in the discussion below will describe features used in construction to minimize or prevent corrosion of embedded steels. The second and third sections will discuss a bounding environment and a representative indicator that can be monitored for the potential of corrosion at the liner to concrete interface. The fourth section will provide direct evidence to support there is no detected loss of material due to general corrosion on the exterior surface of the containment liner.

<u>Construction Features</u>
As discussed in section 3.5.2.2.1.3 of the LRA, concrete meeting the requirements of ACI 318, Building Code Requirements for Reinforced Concrete, and the guidance of ACI 201.2R with

respect to chlorine ion content was used for the containment concrete in contact with the embedded containment liner. This ensures that contact with the concrete containment shell or concrete base mat will not cause corrosion of the reinforcing steel, liner, liner anchors, or other steel elements embedded in the concrete. In addition, the presence of an abundant amount of calcium hydroxide and relatively small amounts of alkali elements, such as sodium and potassium, gives the water in concrete pore solutions a very high alkalinity with pH of 12 to 13. This pH range is where steel (iron) is either thermodynamically "immune" to corrosion or where a protective passive film is thermodynamically stable on the steel surface regardless of the corrosion potential of the steel as affected by the dissolved oxygen content of the water. Steel in contact with low impurity concrete pore water will not suffer significant corrosion even if sufficient moisture and oxygen are available due to the spontaneous formation of this thin protective passive film.

Bounding Environment

The environment (moisture) that exists at the interior side of the tendon tunnel wall adjacent to the contained area described above in the Exelon Background Information section is a bounding environment with respect to the environment that could potentially exist at the concrete containment shell to metal containment liner interface located above these corresponding sections of the tendon tunnels. The tendon tunnel location with respect to the containment building is such that the top of the tendon tunnel is the bottom of the outer edge of the base mat of the containment structure. The tendon tunnel structure is located 12 feet below the containment liner as shown in UFSAR Figures 3.8-1 and 3.8-2. This configuration results in a higher head of water pressure and establishes a preferential flow path for water infiltrating the concrete at the tendon tunnels, which is below and away from the exterior surface of the containment liner. In addition, the Containment Structure is post-tensioned with hoop and vertical tendons, which close up any shrinkage cracks; therefore the Containment Structure is significantly less permeable with respect to water seepage into the concrete than the tendon tunnels, which are not post-tensioned.

Representative Indicator

Corrosion of carbon steel is strongly dependent on dissolved oxygen levels. The reinforcing steel for the containment and tendon tunnel and the containment liner plate are carbon steel materials. The inside surface of the tendon tunnel is exposed to air, while the three feet six inch (3’-6”) thick containment concrete shell was placed directly against the containment liner plate, limiting the oxygen available for potential corrosion. Oxygen levels in any moisture that may migrate or diffuse to the containment liner concrete interface are expected to be very low because any moisture in this area would be stagnated, and depleted oxygen levels will not be replenished. As a result, the embedded reinforcing steel at the inner surface of the tendon tunnel is less protected from corrosion than the exterior surface of the containment liner plate. Therefore, the condition of the embedded reinforcing steel at the inner surface of the tendon tunnel can be used as a representative indicator for the potential for corrosion at the exterior surface of the containment liner plate.

Routine and ongoing visual and hammer sounding inspections performed at the tendon tunnels have not revealed any degradation of concrete embedded steel or rebar or degradation of concrete due to corrosion of embedded steel, leaching, or chemical attack. Mineral deposits have been cleaned away exposing the cracks at various locations; there have been no appreciable changes at the cracks since original construction and minimal redeposit of mineral deposits. Concrete at the crack locations has been determined to be structurally sound. This provides supporting information that the water in-leakage is not degrading the concrete. The

inspection of this representative indicator in a bounding environment and the absence of corrosion of embedded reinforcing steel are used to support the conclusion that corrosion is not occurring at the exterior surface of the containment liner plates. Loss of material due to corrosion of carbon steel embedded in concrete is not expected because even though the groundwater has been characterized as aggressive due to high in chlorides (chlorides > 500 ppm), when a water in-leakage sample taken from the tendon tunnel was tested in 2013, the water was found to be non-aggressive (pH > 5.5, chlorides < 500 ppm, sulfates <1500 ppm). In addition, further evidence will be obtained to support the conclusion that loss of material due to corrosion is not occurring on carbon steel embedded in the tendon tunnel. Enhancement 16 to the Structures Monitoring (B.2.1.34) aging management program, as documented in the response to RAI B.2.1.34-1, will provide this further evidence. This evidence will be obtained by exposing and examining reinforcing steel in the tendon tunnels at locations with water in-leakage and mineral deposits to confirm the absence of loss of material due to corrosion of embedded carbon steel.

Direct Evidence
As discussed in section 3.5.2.2.1.3 of the LRA, numerous ultrasonic examinations of the containment liner at the containment floor level (moisture barrier area) revealed that there is no detected corrosion on the exterior surfaces of the liner that is in contact with the concrete containment shell. At least nine of the twenty-one ultrasonic examinations conducted between 2004 and 2012 located in the moisture barrier areas (i.e., areas near the floor elevation inside containment) were above the portions of the tendon tunnel that are adjacent to the main steam and auxiliary feedwater tunnel. Since the moisture barrier area is near the lowest vertical section of the concrete containment shell to liner interface, it is considered a bounding area for revealing any potential impact of moisture on the exterior surfaces of the containment liner. These ultrasonic examinations provide direct, physical evidence that there is no detected corrosion occurring on the exterior of the containment liner plates.

Conclusion

Based on industry operating experience, as documented in NRC sponsored report, “Sandia Report SAND2010-8718, July 2010 Nuclear Containment Steel Liner Corrosion Workshop: Final Summary and Recommendation Report”, corrosion starting from the concrete side of the liner and corroding through to the interior surface of the liner has only been discovered as a result of foreign material being left in place during original construction. This industry operating experience corroborates the plant specific information and conclusions provided in the previous discussions, which support a conclusion that corrosion will not occur on the concrete side of the containment liner as a result of water infiltrating the concrete.

Ongoing inspections of the concrete in the tendon tunnels, both by the Structures Monitoring (B.2.1.34) aging management program and the ASME Section XI, Subsection IWL (B.2.1.30) aging management program, together with Enhancement 16 to the Structures Monitoring (B.2.1.34) aging management program as discussed in the response to RAI B.2.1.34-1, will ensure that any adverse changes to current conditions will be identified, documented in the corrective action program, and assessed for any potential impact on other structures and areas, including inaccessible areas.

Based on the above, there is no detected loss of material due to general corrosion of the containment liner at the concrete containment shell to liner interface. Therefore, it is reasonable to conclude that the containment liner at the concrete containment shell to liner interface will not

degrade, augmented examinations are not required, and the leak-tight integrity of the carbon steel liner can be adequately managed and maintained through the period of extended operation by the existing ASME Section XI, Subsection IWE (B.2.1.29) aging management program.

RAI B.2.1.29-2

Applicability:

Byron and Braidwood

Background:

LRA Section B.2.1.29 states that the ASME Section XI, Subsection IWE AMP is an existing program that, following enhancement, will be consistent with the GALL Report, Revision 2, AMP XI.S1. The "operating experience" program element recommends that the ASME Section XI, Subsection IWE program consider operating experience regarding liner plate and containment shell corrosion. The applicant should demonstrate that it utilizes industry operating experience in development of the AMP.

There is recent industry operating experience which has indicated that at some plants, the implementation of the IWE program has been ineffective in identifying moisture intrusion into the leak chase channel areas and potential leakage to the containment shell and liner seam welds. This issue is discussed in NRC Integrated Inspection Report 05000348/2012003 and 05000364/2012003 (Joseph M. Farley Nuclear Plant); NRC Integrated Inspection Report 05000395/2011003 (Virgil C. Summer Nuclear Station); and NRC Integrated Inspection Report 05000327/2012005 and 05000328/2012005 (Sequoyah Nuclear Plant). Some licensees were not performing general visual examinations of 100 percent of the containment liner plate leak chase systems in accordance with ASME Code Section XI, Subsection IWE requirements; and upon inspection, moisture was discovered in the leak chase channel system. Moisture intrusion into the leak chase channel system could reach the containment seam welds. This has the potential to cause corrosion at the welds and affect leak-tightness at the containment or liner pressure boundary.

Issue:

Regarding the recent industry operating experience concerning implementation of the 100 percent visual inspection requirements of the ASME Code IWE and the GALL Report recommendation that the applicant consider industry operating experience in development of the ASME Section XI, Subsection IWE AMP, the staff needs additional information for applicability to Byron and Braidwood.

Request:

Considering the recent industry operating experience described above regarding implementation of the IWE visual examinations, inspections of the leak chase channel system, and concerns of standing water or moisture intrusion to the containment liner plate, state what actions have been or will be taken to (1) determine whether there is moisture in the leak chase channel area and (2) ensure the IWE program will be effective in ensuring moisture intrusion and corrosion do not affect the carbon steel containment liner through the PEO.

Exelon Response:

Background

The industry operating experience discussed by the staff in the *Background* section describes discovery of moisture intrusion into the leak chase channel system and in some cases standing water inside the leak chase channels. This industry operating experience also describes that the configuration of the leak chase channel system test connections were normally not visible without removing gasketed cover plates. They were recessed inside a covered floor pit. Consequently, the leak chase channel system test connections and caps were not visually inspected for an extended period of time. When the test connections were inspected, standing water was sometimes found around the leak chase channel system test connections pipe ends. In some cases, the leak chase channel system test connection caps were not installed and moisture intrusion was found inside the leak chase channel system that had resulted in containment liner corrosion.

Byron and Braidwood Actions

Based on this industry experience, action was taken to evaluate the configuration of the leak chase channel system test connections cited in the industry operating experience examples and compared those configurations against the leak chase channel system test connection configuration at Byron and Braidwood. The evaluation determined that leak chase channel system test connection configuration at Byron and Braidwood are different from those cited in the industry experience discussed by the staff in the *Background* section. Specifically, the leak chase channel system test connection pipes at Byron and Braidwood do not end in a pit, rather the pipes extend at least six (6) inches above the containment floor. In addition, the leak chase channel system test connection pipes are all capped and have been capped since initial construction. Therefore, the configuration of the leak chase channel system test connection pipes at Byron and Braidwood does not allow water to collect in a pit or moisture to intrude into a leak chase channel system.

The leak chase channel system test connection pipes and caps are accessible and readily visible. The leak chase channel system test connection pipes and caps are inspected as part of the ASME Section XI IWE (B.2.1.29) aging management program (AMP). There has been no indication of standing water or degradation identified on the leak chase channel system test connection pipes or pipe caps. The continued implementation of the ASME Section XI IWE (B.2.1.29) AMP will provide ongoing assurance that corrosion of the carbon steel containment liner will not occur due to moisture intrusion from the leak chase channel test connection pipes through the period of extended operation.

Conclusion

Based on actual plant experience and the specific configuration of the leak chase channel test connection pipes at Byron and Braidwood, moisture is prevented from intruding into the leak chase channel system. The continued implementation of the ASME Section XI IWE (B.2.1.29) AMP will be effective in ensuring that moisture intrusion and corrosion do not affect the carbon steel containment liner through the period of extended operation.

Enclosure B

Byron and Braidwood Stations, Units 1 and 2
License Renewal Application (LRA) updates resulting from the responses to the following RAIs:

RAI B.3.1.2-1
RAI B.2.1.34-1
RAI B.2.1.30-2

Note: To facilitate understanding, original LRA text has been repeated in this Enclosure, with revisions indicated. Existing LRA text is shown in normal font. Changes are highlighted with ***bolded italics*** for inserted text and ~~strikethroughs~~ for deleted text.

As a result of the response to RAI B.3.1.2-1 provided in Enclosure A of this letter, LRA Section 4.5, pages 4.5-1 and 4.5-2, is revised as shown below. Changes are highlighted with ***bolded italics*** for inserted text and ~~strikethroughs~~ for deleted text.

4.5 CONCRETE CONTAINMENT TENDON PRESTRESS ANALYSIS

TLAA Description:

The Containment Structures at Byron and Braidwood Stations are prestressed concrete shell structures made up of a cylinder with a shallow dome roof and flat foundation slab. The cylindrical portion is prestressed by a post-tensioning system consisting of 201 horizontal and 162 vertical tendons. There are three buttresses equally spaced around the containment and each horizontal tendon is anchored at buttresses 240 degrees apart, bypassing the intermediate buttress. The dome post-tensioning system is made up of 120 tendons (119 for Braidwood Unit 1), which are arranged in three groups oriented 120 degrees to each other and anchored at the vertical face of the dome ring. The base foundation slab is conventionally reinforced concrete with high strength reinforcing steel. The tendons are ungrouted, but enclosed in galvanized steel conduits filled with a corrosion protection medium. Each tendon consists of 170 high strength steel wires, each ¼ inch in diameter.

Over time, the containment prestressing forces decrease due to relaxation of the steel tendons and due to creep and shrinkage of the concrete. The containment tendon prestressing forces were calculated during the original design considering the magnitude of the tendon relaxation and concrete creep and shrinkage over the 40-year life of the plant. The ASME Section XI, Subsection IWL (B.2.1.30) program performs periodic surveillances of individual tendon prestressing values. Predicted lower limit (PLL) force values are calculated for each tendon prior to the surveillances to estimate the magnitude of the tendon relaxation and concrete creep and shrinkage for the given surveillance year. ~~The~~ ***Individual tendon*** prestressing force~~s~~ ***values*** are measured and plotted, and trend lines are developed, to ensure the~~ average~~ tendon group prestressing values remain above the respective minimum required values (MRVs) until the next scheduled surveillance, and potentially for the 40-year period. The predicted lower limit force values and regression analyses, utilizing actual ***individual*** measured tendon forces, are used to evaluate the acceptability of the containment structure to perform its intended function over the current 40-year life of the plant, and therefore, are TLAAs requiring evaluation for the period of extended operation.

TLAA Evaluation:

Predicted Lower Limit (PLL)

The containment tendon prestressing force values were calculated during the original design of the containment structure to determine the initial prestressing force required for each tendon group such that the prestressing force would remain above the respective MRVs over the 40-year life of the plant. The initial tendon prestressing force was calculated for each tendon type to compensate for the steel tendon relaxation losses and concrete creep and shrinkage so that the estimated final effective tendon

prestressing force at the end of the 40 years would be higher than the minimum required values (MRVs).

As part of the ASME Section XI, Subsection IWL inspections related to tendon examinations, PLL force values are calculated for each individual tendon scheduled for examination, for the given surveillance year. The PLL force values are developed consistent with the guidance presented in Regulatory Guide 1.35.1 (Reference 4.8.21). Actual measured values for each tendon are compared to their respective PLL values, with acceptance criteria consistent with ASME Section XI, Subsection IWL requirements.

Regression Analysis

A regression analysis is developed for each of the three tendon groups to determine the trend over time in prestressing values of individual tendons within each tendon group. The regression analysis consists of a trend line utilizing actual individual tendon prestressing forces measured during successive ASME Section XI, Subsection IWL surveillances, consistent with NRC Information Notice 99-10, Attachment 3 (Reference 4.8.22). The trend lines are periodically updated with new tendon prestressing force data ***for individual tendons*** following each surveillance. The trend lines are used to demonstrate that the ~~average~~ ***tendon*** group prestressing forces will remain above the group MRV until the next scheduled surveillance, and potentially for the life of the plant.

As a result of the response to RAI B.3.1.2-1 provided in Enclosure A of this letter, LRA Appendix B, Section B.3.1.2, pages B-284 and B-285, is revised as shown below. Changes are highlighted with ***bolded italics*** for inserted text and ~~strikethroughs~~ for deleted text.

B.3.1.2 Concrete Containment Tendon Prestress

Program Description

The Concrete Containment Tendon Prestress aging management program is an existing program that is predicated on the ASME Section XI, Subsection IWL requirements. The program is based on the 2001 Edition, through the 2003 Addenda, of the ASME Boiler and Pressure Vessel Code, Section XI and includes confirmatory actions that monitor loss of containment tendon prestressing forces during the current term and will continue through the period of extended operation.

The program requires measurement of prestressing forces on an initial 2% sample of each tendon group (dome, hoop, vertical) every five years, as specified in IWL-2400. One tendon in each group sample is identified as a common, or control, tendon and is tested during each successive surveillance. The remaining tendons in the sample are obtained by randomly selecting tendons from amongst all of those that have not been previously examined. The initial sample size, which may be expanded if unacceptable conditions are found, is established as specified in Table IWL-2521-1.

Assessments of the results of the tendon prestressing force measurements are performed in accordance with ASME Section XI, Subsection IWL to confirm adequacy of the prestressing forces. The assessment consists of the establishment of acceptance criteria and trend lines. The acceptance criteria consist of predicted values on the forces in individual tendons and the minimum required prestressing force or value (MRV). The predicted value, or predicted lower limit (PLL), for individual tendons is developed consistent with the guidance presented in Regulatory Guide 1.35.1. As long as individual tendon forces remain above 95% of predicted values, there is definitive evidence that actual prestressing force loss is not significantly greater than that allowed for in the original design calculations.

Trend lines, one for each tendon group, are constructed using the ***individual*** measured tendon forces and represent the changes in ~~mean~~ vertical, hoop and dome prestressing forces with time. Trend line regression analysis is consistent with NRC Information Notice 99-10. As long as the trend lines do not fall below the MRV's prior to the next scheduled surveillance, the tendon prestress force is acceptable. In accordance with the requirements of 10 CFR 50.55a(b)(2)(viii)(B), an evaluation will be performed if the trend lines predict the prestressing forces in the containment to be below the MRV before the next scheduled inspection.

A new analysis was performed for Byron and Braidwood Stations based on actual measured forces to establish the trend of prestressing forces through the end of the period of extended operation. The analysis evaluates force trends by group (dome, hoop, vertical) and shows that group ~~mean~~ forces will not fall below applicable MRV's prior to the end of the period of extended operation. However, as tendon force trends may vary with time, the conclusions regarding long-term performance of the post-tensioning system are subject to change. As a result, the regression analyses are

periodically updated to account for data acquired during future surveillances.

Loss of containment tendon prestressing forces is a Time-Limited Aging Analysis (TLAA) evaluated in accordance with 10 CFR 54.21(c)(1)(iii). This program is credited for managing loss of containment tendon prestressing forces through the period of extended of operation.

As a result of the response to RAI B.2.1.34-1 provided in Enclosure A of this letter, LRA Appendix A, Section A.2.1.34, page A-38, is revised to add Enhancement 16 as shown below. Pre-existing text from the LRA is formatted in normal font. Additions are highlighted with ***bolded italics***.

A.2.1.34 Structures Monitoring

The Structures Monitoring aging management program will be enhanced to:

16. At each site, perform one-time sampling activities on below grade, reinforced concrete at specific locations in the tendon tunnels. Select the locations exhibiting significant mineral deposits to serve as leading indicators for potential reinforced concrete degradation as a result of exposure to ground water in-leakage and build-up of mineral deposits. Take corrective actions, if necessary, prior to the period of extended operation. Perform the one-time sampling activities as follows:

- ***a. Obtain water in-leakage samples, at representative locations with mineral deposits due to water in-leakage, and analyze for pH, chlorides, sulfates, minerals, and iron content.***
- ***b. Obtain representative mineral deposit samples and analyze for chemical composition.***
- ***c. Remove three concrete core samples.***
  - ***i. Test two of the concrete core samples for compressive strength and perform petrographic examination of the core samples. Select representative locations for the concrete core samples that include one with significant mineral deposits and another at a location with no mineral deposits for comparative purposes.***
  - ***ii. Drill an additional core at a crack with significant mineral deposits and subject the core to petrographic examination.***
- ***d. Expose and examine reinforcing steel at two locations, with water in-leakage, cracks, and significant mineral deposits.***
- **e.** ***Collectively evaluate the results from the water in-leakage analysis, the chemical composition of the mineral deposits, examination of the exposed reinforcing steel, and the core sample testing to confirm there is no significant degradation to the reinforced concrete material properties and to determine if additional corrective actions are necessary. Additional corrective actions may include, but are not limited to, an extent of condition review for other potentially impacted structures, more frequent examinations, and additional sampling and analysis, as appropriate.***

These enhancements will be implemented prior to the period of extended operation.

As a result of the response to RAI B.2.1.34-1 provided in Enclosure A of this letter, LRA Appendix B, Section B.2.1.34, page B-225, is revised to add Enhancement 16 as shown below. Pre-existing text from the LRA is formatted in normal font. Additions are highlighted with ***bolded italics***.

B.2.1.34 Structures Monitoring

Enhancements

Prior to the period of extended operation, the following enhancements will be implemented in the following program elements:

16. ***At each site, perform one-time sampling activities on below grade, reinforced concrete at specific locations in the tendon tunnels. Select the locations exhibiting significant mineral deposits to serve as leading indicators for potential reinforced concrete degradation as a result of exposure to ground water in-leakage and build-up of mineral deposits. Take corrective actions, if necessary, prior to the period of extended operation. Perform the one-time sampling activities as follows:***

    a) ***Obtain water in-leakage samples, at representative locations with mineral deposits due to water in-leakage, and analyze for pH, chlorides, sulfates, minerals, and iron content.***

    b) ***Obtain representative mineral deposit samples and analyze for chemical composition.***

    c) ***Remove three concrete core samples.***

        i. ***Test two of the concrete core samples for compressive strength and perform petrographic examination of the core samples. Select representative locations for the concrete core samples that include one with significant mineral deposits and another at a location with no mineral deposits for comparative purposes.***

        ii. ***Drill an additional core at a crack with significant mineral deposits and subject the core to petrographic examination.***

    d) ***Expose and examine reinforcing steel at two locations, with water in-leakage, cracks, and significant mineral deposits.***

    e) ***Collectively evaluate the results from the water in-leakage analysis, the chemical composition of the mineral deposits, examination of the exposed reinforcing steel, and the core sample testing to confirm there is no significant degradation to the reinforced concrete material properties and to determine if additional corrective actions are necessary. Additional corrective actions may include, but are not limited to, an extent of condition review for other potentially impacted structures, more frequent examinations, and additional sampling and analysis, as appropriate.***

Program Elements Affected: Detection of Aging Affects (Element 4)

As a result of the response to RAI B.2.1.30-2 provided in Enclosure A of this letter, LRA Section 2.4.4, pages 2.4-25 and 2.4-26, is revised as shown below. This section was previously revised as a result of the response to RAI 2.1-3 provided in Exelon Letter RS-13-274, dated December 19, 2013. Pre-existing text, from the LRA and from a response to a previous request for additional information, is formatted in normal font. Additions are highlighted with ***bolded italics***.

2.4.4 Containment Structure

Description

Exterior Structural Features:

In addition, the Containment Structure includes the following exterior structural features: a tendon access gallery, a buttress and walkway enclosure, shielding outside of the personnel lock with equipment hatch***,*** and the portions of the containment access facility hallway that are in contact with, or immediately adjacent to, the shielding outside of the personnel lock with equipment hatch.

Tendon Access Gallery - The annular reinforced concrete tendon access gallery is below the base slab of the containment buildings. The tendon gallery provides access to the bottom of the tendon anchorage and provides shelter and protection to the tendon anchorage.

Buttress and Walkway Enclosure - The exterior buttress and walkway enclosures contain the ladders and access platforms that provide access to the tendon anchorages at the vertical buttresses and around the outside edge of the dome. ***A concrete curb on the dome supports the inner radius of the walkway enclosure. The containment dome drains are provided in the concrete curbing to drain water from this area. The exterior buttress and walkway are constructed of steel framing and metal siding.*** The exterior buttress and walkway enclosures provide shelter and protection to the tendon anchorage. The ladders and access platforms inside of these enclosures, on the outside of the containment building wall, while providing access to the tendon anchorages for inspection, do not perform an intended function and their failure would not impact a safety-related function.

Shielding Outside of the Personnel Lock with Equipment Hatch - The personnel lock with equipment hatch is equipped with a concrete external shielding to allow access into the containment building for personnel and large equipment. The external shielding is evaluated as a containment building element and acts as a radiation and missile shield.

Containment Access Facility Hallway - The containment access facility hallway provides shelter and protection to the shielding outside of the personnel lock with equipment hatch.

Enclosure C

Byron and Braidwood Stations (BBS) Units 1 and 2
License Renewal Commitment List Changes

This Enclosure identifies commitments made in this document and is an update to the Byron and Braidwood Station (BBS) LRA Appendix A, Table A.5 License Renewal Commitment List. Any other actions discussed in the submittal represent intended or planned actions and are described to the NRC for the NRC's information and are not regulatory commitments. Changes to the BBS LRA Appendix A, Table A.5 License Renewal Commitment List are as a result of the Exelon response to the following RAI:

RAI B.2.1.34-1

Notes:

- To facilitate understanding, portions of the original License Renewal Commitment List have been repeated in this Enclosure, with revisions indicated.
- Existing LRA text is shown in normal font. Changes are highlighted with ***bolded italics*** for inserted text.

As a result of the response to RAI B.2.1.34-1 provided in Enclosure A of this letter, LRA Appendix A, Table A.5 License Renewal Commitment List, line item 34 on page A-87, is revised to add Enhancement 16 as shown below. Pre-existing text, from the LRA, is formatted in normal font. Additions are highlighted with ***bolded italics***.

A.5 LICENSE RENEWAL COMMITMENT LIST

NO.	PROGRAM OR TOPIC	COMMITMENT	IMPLEMENTATION SCHEDULE	SOURCE
34	Structures Monitoring	Structures Monitoring is an existing program that will be enhanced to: ***16. At each site, perform one-time sampling activities on below grade, reinforced concrete at specific locations in the tendon tunnels. Select the locations exhibiting significant mineral deposits to serve as leading indicators for potential reinforced concrete degradation as a result of exposure to ground water in-leakage and build-up of mineral deposits. Take corrective actions, if necessary, prior to the period of extended operation. Perform the one-time sampling activities as follows:*** ***a. Obtain water in-leakage samples, at representative locations with mineral deposits due to water in-leakage, and analyze for pH, chlorides, sulfates, minerals, and iron content.*** ***b. Obtain representative mineral deposit samples and analyze for chemical composition.*** ***c. Remove three concrete core samples.*** ***i. Test two of the concrete core samples for compressive strength and perform petrographic examination of the core samples. Select representative locations for the concrete core samples that include one with significant mineral deposits and another at a location with no mineral deposits for comparative purposes.*** ***ii. Drill an additional core at a crack with significant mineral deposits and subject the core to petrographic examination.*** ***d. Expose and examine reinforcing steel at two locations, with water in-leakage, cracks, and significant mineral deposits.***	Program to be enhanced prior to the period of extended operation. .	Section A.2.1.34 ***Exelon letter RS-14-097 04/17/2014*** ***RAI B.2.1.34-1***

NO.	PROGRAM OR TOPIC	COMMITMENT	IMPLEMENTATION SCHEDULE	SOURCE
		e. Collectively evaluate the results from the water in-leakage analysis, the chemical composition of the mineral deposits, examination of the exposed reinforcing steel, and the core sample testing to confirm there is no significant degradation to the reinforced concrete material properties and to determine if additional corrective actions are necessary. Additional corrective actions may include, but are not limited to, an extent of condition review for other potentially impacted structures, more frequent examinations, and additional sampling and analysis, as appropriate.		