ComEd

Commonwealth Edison Company
Quad Cities Generating Station
22710 206th Avenue North
Cordova, IL 61242-9740

www.exeloncorp.com

An Exelon Company

November 30, 2000

SVP-00-178

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

Quad Cities Nuclear Power Station, Units 1 and 2
Facility Operating License Nos. DPR-29 and DPR-30
NRC Docket Nos. 50-254 and 50-265

Subject: Risk Informed Inservice Inspection Program
Alternative to the ASME Boiler and Pressure Vessel Code Section XI
Requirements for Class 1and 2 Piping Welds

References: (1) Electric Power Research Institute (EPRI) Topical Report (TR) 112657 Revision B, "Revised Risk-Informed Inservice Inspection Evaluation Procedure"

(2) W. H. Bateman (U. S. NRC) to G. L. Vine (EPRI) letter dated October 28, 1999 transmitting "Safety Evaluation Report Related to EPRI Risk-Informed Inservice Inspection Evaluation Procedure (EPRI TR-112657, Revision B, July 1999)"

In accordance with 10 CFR 50.55a "Codes and Standards" paragraph (a)(3)(i), Quad Cities Nuclear Power Station (QCNPS) is submitting, for U. S. Nuclear Regulatory Commission (NRC) approval, a proposed alternative to existing American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," requirements for the selection and examination of Class 1 and 2 piping welds. The alternative proposed by QCNPS uses the Reference (1) methodology for a Risk-Informed Inservice Inspection (RISI) program approved by the NRC to the extent and within the limitations specified in Reference (2).

Relief Request CR-33 and a summary of the RISI Program Plan is attached and demonstrates that the proposed alternative would provide an acceptable level of quality and safety, as required by 10CFR 50.55a (a)(3)(i). The format of QCNPS RISI submittal is consistent with the Nuclear Energy Institute and industry template developed for applications of the RISI methodology. Additional supporting documentation is available at QCNPS for NRC review.

A047

Quad Cities plans to incorporate the RISI program during the third period of the third interval for both Units 1 and 2. For Unit 1, the third Inservice Inspection Interval began on February 18, 1993 and the projected end date is February 17, 2003. For Unit 2, the third Inservice Inspection Interval began on March 10, 1993 and the projected end date is March 9, 2003.

We intend to incorporate the risk based approach to the selection and examination of Class 1 and 2 piping welds for the remaining period of this third interval for both units. In addition, welds within the plant that are assigned to Intergranular Stress Corrosion Cracking (IGSCC) Catergories B through G will continue to meet the existing IGSCC schedules. However, Category A welds that were formerly a part of the IGSCC program will be subsumed into the RISI Program.

In order to effectively incorporate the risk informed alternative in the winter 2002 outage for Unit 2, we are requesting approval by June 2001.

Should you have any questions concerning this letter, please contact Mr. C.C. Peterson at (309) 654-2241, extension 3609.

Respectfully,

Joel P. Dimmette, Jr.
Site Vice President
Quad Cities Generating Station

Attachments:

Attachment 1: Relief Request CR-33
Attachment 2: Risk-Informed Inservice Inspection Plan – Quad Cities Nuclear Power Station Units 1 and 2

cc: Regional Administrator – NRC Region III
NRC Senior Resident Inspector – Quad Cities Generating Station

Attachment 1

SVP-00-178

ISI Program Plan
Quad Cities Nuclear Power Station
Units 1 and 2
Third Interval

Relief Request CR-33

RELIEF REQUEST CR-33

COMPONENT IDENTIFICATION

Code Class:	1 and 2
Examination Category:	B-F, B-J, C-F-1, and C-F-2
Examination Item Numbers:	B5.10, B5.20, B5.130, B5.150, B9.11, B9.21, B9.31, B9.32, B9.40, C5.11, C5.41, C5.51, and C5.81
Description:	Alternate Selection Criteria for Class 1 Pressure Retaining Dissimilar Metal Welds and Pressure Retaining Welds in Piping and Class 2 Pressure Retaining Welds in Austenitic Stainless or High Alloy Steel and Carbon or Low Alloy Steel piping.
Component Number:	All welds in ASME Section XI Code Categories B-F, B-J, C-F-1, and C-F-2
References:	1) Electric Power Research Institute (EPRI) Topical Report (TR) 112657 Rev.B-A, "Revised Risk-Informed Inservice Inspection Evaluation Procedure" 2) W. H. Bateman (U. S. NRC) to G. L. Vine (EPRI) letter dated October 28, 1999 transmitting "Safety Evaluation Report Related to EPRI Risk-Informed Inservice Inspection Evaluation Procedure (EPRI TR-112657, Revision B, July 1999)" 3) Risk-Informed Inservice Inspection Evaluation - Quad Cities Nuclear Power Station Units 1 and 2 (August 2000) 4) American Society of Mechanical Engineers (ASME) Code Case N-578-1, "Risk-Informed Requirements for Class 1, 2, or 3 Piping, Method B"

CODE REQUIREMENT

Table IWB 2500-1, Examination Category B-F, requires a volumetric and/or surface examination on all welds for Items B5.10, B5.20, B5.130, and B5.150.

Table IWB 2500-1, Examination Category B-J, requires a volumetric and/or surface examination on welds for Items B9.11, B9.21, B9.31, B9.32, and B9.40. QCNPS Third Interval Inspection Plan Relief Request CR-02, "Selection of Class 1 Piping Welds for

RELIEF REQUEST CR-33

Examination" provides an approved alternative to the Table IWB 2500-1, Examination Category B-J extent and frequency requirements for Items B9.11, B9.21, B9.31, B9.32, and B9.40. As stated in CR-02, QCNPS selects Category B-J welds such that 25% of the total non-exempt welds are examined during the interval (and subsequent intervals). The weld population selected for inspection includes the following:

1. All accessible terminal end welds in each pipe or branch run connected to vessels.

2. All accessible terminal end welds in each pipe or branch run connected to other components.

3. All dissimilar metal welds between combinations of:

   a. carbon or low alloy steels to high alloy steels;

   b. carbon or low alloy steels to high nickel alloys;

   c. high alloy steels to high nickel alloys.

4. Additional piping welds so that the total number of circumferential butt welds (or branch connection or socket welds) selected for examination equals 25% of the circumferential butt welds (or branch connection or socket welds) in the reactor coolant piping system. This total does not include welds excluded by IWB-1220.

Table IWC-2500-1, Examination Categories C-F-1 and C-F-2 require volumetric and surface examinations for Items C5.11, C5.41, C5.51, and C5.81. The Category C-F-1 and C-F-2 weld population selected for inspection includes the following:

1. Welds selected shall include 7.5%, of all austenitic or high alloy steel welds (Category C-F-1) or of all carbon and low alloy steel welds (Category C-F-2). Some welds not exempted by IWC-1220 are not required to be nondestructively examined per Examination Categories C-F-1 and C-F-2. These welds, however, shall be included in the total weld count to which the 7.5% sampling rate is applied. The examinations shall be distributed as follows:

   a. the examinations shall be distributed among the Class 2 systems prorated, to the degree practicable, on the number of nonexempt austenitic or high

RELIEF REQUEST CR-33

alloys welds (Category C-F-1) or carbon and low alloy welds (Category C-F-2) in each system (i.e., if a system contains 30% of the nonexempt welds, then 30% of the nondestructive examinations required by the Examination Category (C-F-1 or C-F-2) shall be performed on that system);

b. within a system, the examinations shall be distributed among terminal ends and structural discontinuities prorated, to the degree practicable, on the number of nonexempt terminal ends and structural discontinuities in the system; and

c. within each system, examinations shall be distributed between line sizes prorated to the degree practicable.

BASIS FOR RELIEF

Pursuant to 10 CFR 50.55a(a)(3)(i), relief is requested on the basis that the proposed alternative would provide an acceptable level of quality and safety. As stated in the Reference 2 evaluation:

> "The staff concludes that the proposed RISI program as described in EPRI TR-112657, Revision B, is a sound technical approach and will provide an acceptable level of quality and safety pursuant to 10 CFR 50.55a for the proposed alternative to the piping ISI requirements with regard to the number of locations, locations of inspections, and methods of inspection."

In lieu of the evaluation and sample expansion requirements of Section 3.6.6.2, "RISI Selected Examinations," contained in Reference 1, Quad Cities will utilize the requirements of Subarticle-2430, "Additional Examinations" which is contained in Code Case N-578-1 (Reference 4) which is a more refined methodology for implementing necessary additional examinations.

To supplement the requirements listed in Table 4-1, "Summary of Degradation-Specific Inspection Requirements and Examination Methods" of EPRI TR-112657, Quad Cities will utilize the provisions listed in Table 1, Examination Category R-A, "Risk-Informed Piping Examinations" of Reference 4. Table 1 of Code Case N-578-1 provides more refined guidance for examination method and categorization for parts to be examined.

PROPOSED ALTERNATE PROVISIONS

RELIEF REQUEST CR-33

The proposed alternative, as described in the attached "Risk Informed Inservice Inspection Plan, Quad Cities Nuclear Power Station, Units 1 and 2," from Reference 3, provides an acceptable level of quality and safety as required by 10 CFR 50.55a(a)(3)(i).

Our application of the Risk Informed ISI, per Reference 1, requires that 25% of the elements that are categorized as "High" risk (Risk Category 1, 2, or 3) and 10% of the elements that are categorized as "Medium" risk (Risk Categories 4 and 5) be selected for inspection. For this application, the guidance for the examination volume for a given degradation mechanism is provided by EPRI TR-112657 while the guidance for examination is provided by EPRI TR-112657 and supplemented by Code Case N-578-1 for examination method and categorization for parts to be examined.

In addition, all piping components, regardless of risk classification, will continue to receive Code-required pressure and leak testing, as part of the current ASME Section XI program. VT-2 visual examinations are scheduled in accordance with Quad Cities pressure and leak test program, which remains unaffected by the risk informed ISI program.

APPLICABLE TIME PERIOD

Relief is requested for the remainder of the third inspection period of the third ten-year interval for Unit 1 and the entire third inspection period of the third ten-year interval for Unit 2.

Attachment 2

SVP-00-178

Risk Informed Inservice Inspection Program Plan

Quad Cities Nuclear Power Station
Units 1 and 2

Table of Contents

1. INTRODUCTION

2. PROPOSED ALTERNATIVE TO CURRENT ISI PROGRAM

2.1 ASME Section XI

2.2 Alternative RISI Program

2.3 Augmented Programs

2.4 Multiple Damage Mechanisms

3. RISK-INFORMED ISI PROCESS

3.1 Definition of RISI Program Scope

3.2 Consequence Analysis

3.3 Degradation Mechanism Assessment

3.4 Risk Characterization

3.5 Inspection Location Selection and NDE Selection

3.6 Program Relief Requests

3.7 Risk Impact Assessment

4. IMPLEMENTATION AND MONITORING PROGRAM

5. PROPOSED ISI PROGRAM PLAN CHANGE

6. REFERENCES

I. Introduction

The objective of this submittal is to request the use of a risk-informed inservice inspection (RISI) program for Class 1 and Class 2 piping that is currently inspected as part of the ASME Section XI based ISI program, as an alternative to the 1989 Edition of the ASME Section XI requirements for the remainder of the third inspection interval. The risk-informed process used in this submittal is described in EPRI RISI Evaluation Procedure (Reference 1). To strengthen the technical basis for this RISI program beyond the minimum requirements implied by the EPRI RISI Topical Report, a number of enhancements were made to the process that are described in the paragraphs below.

ComEd plans to incorporate the RISI inspection program during the third period of the third inspection interval for Quad Cities Units 1 and 2. The Third Inservice Inspection Interval started on February 18, 1993 for Quad Cities Unit 1, and the projected end date is February 17, 2003 (includes all extensions currently being taken). The Third Inservice Inspection Interval started on March 10, 1993 for Quad Cities Unit 2, and the projected end date is March 9, 2003 (includes all extensions currently being taken).

As a risk-informed application, this submittal meets the intent and principles of Regulatory Guides 1.174 and 1.178 as well as those set forth in Reference 1.

<u>PRA Quality</u>

The NRC Staff reviewed the Quad Cities IPE relative to the requirements in NRC Generic Letter 88-20. The July 9, 1997, addendum to the NRC Staff Evaluation Report stated that, "The licensee made several revisions in its analysis to address the Staff's concerns in both submittals and incorporated several plant modifications in the updated IPE, including the addition of two SBO diesel generators. On the basis of its review of the modified IPE and the updated IPE submittals, the Staff concludes that the Quad Cities IPE has met the intent of GL 88-20."

ComEd has significantly upgraded the Quad Cities PRA since the addendum to the NRC Staff Evaluation Report was issued. Much of this upgrade was based on the results of the BWROG PRA Peer Review/Certification of the Dresden PRA in January 1998. The upgrade of the Quad Cities PRA was done in parallel with an upgrade of the Dresden Nuclear Power Station PRA and has produced PRAs of comparable quality. Quad Cities and Dresden Nuclear Plants are plants with similar designs. ComEd had essentially the same personnel working on each of the PRA upgrades. Common enhancements to both plants PRAs included conversion to linked fault trees, addition of special initiators, update of initiating events data, revision of human reliability analysis, update of equipment failure rate, unavailability data and Common Cause Factors, and upgrading Event Tree Analysis. The BWROG PRA Certification Peer Review of the Quad Cities PRA took place in November 1999.

The BWROG PRA Peer Review/Certification process assesses a PRA in eleven functional elements. Each element is graded on a scale of 1 to 4. A grade 3 indicates "that risk significance determinations made by the PRA are adequate to support regulatory applications, when combined with deterministic insights." A grade of 4 indicates that the PRA "is usable as a primary basis for developing licensing positions..." However, "it is expected that few PRA's would currently have many elements eligible for this grade." The Quad Cities PRA was graded 3 in ten of the PRA elements and 4 in the eleventh.

ComEd maintains and updates each of its PRAs to be representative of the respective as-built, as-operated plant. A PRA Maintenance and Update Procedure formalizes the PRA update process. The procedure defines the process for regular and interim updates for issues identified as potentially affecting the PRA. This process assures the present PRA reflects the current plant configuration and plant procedures.

Based on the results of past NRC Staff reviews and the BWROG PRA Certification Peer Reviews, ComEd believes that the level of detail and quality of the Quad Cities PRA fully supports the Quad Cities Risk Informed ISI Relief Request.

2. PROPOSED ALTERNATIVE TO CURRENT ISI PROGRAM REQUIREMENTS

2.1 ASME Section XI

ASME Section XI Categories B-F, B-J, C-F-1, and C-F-2 currently contain the requirements for examining these Class 1 and Class 2 piping components via Non Destructive Examination (NDE) methods.

2.2 Alternate RISI Program

The alternative RISI program for piping is described in EPRI Topical Report (Reference 1). The RISI program will be substituted for the 1989 ASME Section XI Code Edition examination program for Class 1 Category B-J and B-F welds and Class 2 Category C-F-1 and C-F-2 welds in accordance with 10 CFR 50.55a(a)(3)(i) by alternatively providing an acceptable level of quality and safety. Other portions of the ASME Section XI Code imposed inservice inspection program outside of this RISI scope will be unaffected. The EPRI Reference 1 Report provides the requirements for defining the relationship between the risk-informed examination program and the remaining unaffected portions of ASME Section XI.

2.3 Augmented Programs

As discussed in Section 6 of the EPRI Topical Report, certain augmented inspection programs may be integrated into the RISI program. Per Table 6-2 of the EPRI Topical Report, the issues raised by NRC Bulletin 88-08 are all addressed by the evaluation of thermal fatigue that is part of the degradation assessment for RISI. These augmented programs are therefore subsumed in

the RISI program. The following augmented programs were not subsumed into the RISI program and remain unaffected:

- IGSCC in BWR Austenitic Stainless Steel Piping (Generic Letter 88-01 and NUREG-0313). Categories B through G will continue to meet the exisiting IGSCC schedules. However, Category A welds that were formerly a part of the IGSCC program will be subsumed into the RISI Program.
- Service Water Integrity Program (Generic Letter 89-13)
- Flow Accelerated Corrosion (FAC) (Generic Letter 89-08)
- High Energy Line Breaks (USNRC Branch Technical Position MEB 3-1)

Elements in the scope of this evaluation that were also covered by these augmented programs were included in the consequence assessment, degradation assessment, and risk categorization evaluations, to determine whether the affected piping was subject to damage mechanisms other than those addressed by the augmented program. If no other damage mechanism was identified, the element was removed from the RISI element selection population and retained in the appropriate augmented inspection program. If another damage mechanism was identified, the element was retained within the scope of consideration for element selection as part of the RISI program. In the Main Feedwater System, many of the elements covered by the Flow Accelerated Corrosion (FAC) program were also assessed for the potential for other damage mechanisms that are evaluated as part of the EPRI RISI methodology.

2.4 Multiple Damage Mechanisms

The vast majority of pipe elements that were evaluated in the RISI evaluation were found to be susceptible to none of the damage mechanisms addressed in the EPRI RISI methodology. A number of elements were found to be susceptible to one specific damage mechanism, and a relatively small number were identified to be subject to the potential for two or more damage mechanisms. Specific examples are welds in the Main Feedwater System that are subject to both FAC and thermal fatigue, as well as welds in the Shutdown Cooling and Residual Heat Removal systems that have the potential for both IGSCC and thermal fatigue. If one of the damage mechanisms was FAC, the element was assigned to the High failure potential category to be consistent with the EPRI Topical Report. If that assignment led to the decision to select that element for inspection in accordance with the 25% sampling requirement, it was retained in the FAC program for inspection for FAC as well as inspected for the remaining damage mechanism as part of the RISI program. The potential for synergy between two or more damage mechanisms working on the same location was considered in the estimation of pipe failure rates and rupture frequencies which was reflected in the risk impact assessment.

3. RISK-INFORMED ISI PROCESS

The process used to develop the RISI program is consistent with the methodology described in the EPRI Topical Report for ASME Code Case N-578-1 (Reference 7) applications. The process involves the following steps:

- Definition of RISI Program Scope
- Consequence Analysis
- Degradation Mechanism Assessment
- Risk Categorization
- Inspection Location Selection and NDE Selection
- Program Relief Requests
- Risk Impact Assessment
- Implementation and Monitoring Program

3.1 Definition of RISI Program Scope

The systems to be included in the RISI program are provided in Table 1. This scope covers ASME Class 1 and 2 piping systems within the scope of the existing ASME Section XI inspection program. The as-built and as-operated isometric and piping and instrumentation diagrams and additional plant information were used to define the system boundaries. The RISI evaluation system boundaries were defined using the system boundaries established in the existing plant ISI program.

3.2 Consequence Analysis

The consequences of pressure boundary failures were evaluated and ranked based on their impact on conditional core damage probability (CCDP) and conditional large early release probability (CLERP). The impact on these measures due to both direct and indirect effects was determined using the PRA model described in Section 1. Consequence categories (High, Medium or Low) were assigned according to Table 3-1 of the EPRI Topical Report (Reference 1). One of the enhancements that was incorporated into this application of the EPRI RISI methodology was the direct use of the PRA models to support the estimation of CCDP and CLERP values for each pipe element in the scope of the RISI evaluation, in lieu of the consequence tables in the EPRI Topical Report. This step was taken to reduce some of the conservatisms inherent in the consequence tables and to support a more complete and realistic quantification of the risk impacts of the RISI program in comparison with previous applications of this methodology. Another motivation was to increase consistency with other risk informed applications at ComEd that directly utilize the plant-specific PRA models.

3.3 Degradation Mechanism Assessment

Failure potential was assessed using the deterministic criteria in the EPRI Topical Report to evaluate the potential for each damage mechanism that an ISI exam could identify, and supported by industry failure history, plant-specific failure history, and other relevant information. These failure estimates were determined using the guidance provided in the EPRI Topical Report.

Table 2 summarizes the degradation mechanism assessment by system for each damage mechanism that was identified as a potential failure cause. In addition, failure rates and rupture

frequencies were assessed for each piping element within the scope of the RISI evaluation using information in Reference 6 and described in the Tier 2 documentation (Reference 4).

3.4 Risk Categorization

In the preceding steps, each element within the scope of the RISI program was evaluated to determine the consequences of its failure, as measured by CCDP and CLERP. Each element was also evaluated to determine its potential for pipe rupture based on the potential for degradation mechanisms that were identified. The results of the consequence assessment were then combined with the results of the degradation assessment, using the risk matrix shown in Figure 1. This provides a risk ranking and risk category for each element.

POTENTIAL FOR PIPE RUPTURE PER DEGRADATION MECHANISM SCREENING CRITERIA	**CONSEQUENCES OF PIPE RUPTURE** IMPACTS ON CONDITIONAL CORE DAMAGE PROBABILITY AND LARGE EARLY RELEASE PROBABILITY			
	NONE	LOW	MEDIUM	HIGH
HIGH FLOW ACCELERATED CORROSION	LOW Category 7	MEDIUM Category 5	HIGH Category 3	HIGH Category 1
MEDIUM OTHER DEGRADATION MECHANISMS	LOW Category 7	LOW Category 6	MEDIUM Category 5	HIGH Category 2
LOW NO DEGRADATION MECHANISMS	LOW Category 7	LOW Category 7	LOW Category 6	MEDIUM Category 4

Figure 1

EPRI RISI Matrix for Risk Ranking of Pipe Segments (Reference 1)

The results of this evaluation in terms of the number of elements in each of the EPRI RISI risk categories per system are summarized in Table 3 and Table 4 for Quad Cities Unit 1 and Unit 2, respectively.

3.5 Inspection Location Selection and NDE Selection

In general, an ASME Code Case N-578-1 application of RISI, per the EPRI RISI Topical Report, requires that 25% of the elements that are categorized as "High" risk (Risk Category 1, 2, or 3) and 10% of the elements that are categorized as "Medium" risk (Risk Categories 4 and 5) be

selected for inspection and appropriate non-destructive examination (NDE). Inspection locations are generally selected on a system-by-system basis, so that each system with "High" risk category elements will have approximately 25% of the system's "High" risk elements selected for inspection and similarly 10% of the elements in systems having "Medium" risk category welds will be selected. During the selection process, an attempt is made to ensure that all damage mechanisms and all combinations of damage mechanisms are represented in the elements selected for inspection. An element ranking process was used to incorporate several factors into the selection of specific elements to satisfy the above sampling percentages. These factors include whether the element has been previously selected for ISI exams, whether previous exams had indications of possible damage, presence of radiation fields in the vicinity of the elements, accessibility of the element for inspection, and numerical estimates of the pipe rupture frequencies at these locations. The results of the selection are presented in Tables 5 and 6 for Units 1 and 2, respectively. Section 4 of the EPRI Topical Report and ASME Code Case N-578-1 (Reference 7) were used as guidance in determining the examination methods and requirements for these locations. From the Class 1 butt welded elements that were considered within the scope of the RISI evaluation at Unit 1, a total of 17.0% were selected for volumetric examination as part of the risk informed inspection program. Of the smaller amount of Class 1 socket welded elements that were considered within the scope of the RISI evaluation, none were selected for a risk informed examination. The corresponding percentages for Unit 2 were 15.6% and 0%, respectively. The total Class 1 welds selected for RISI evaluation was 13.3% for Unit 1 and 12.5% for Unit 2. As noted above, elements found to be susceptible to two or more damage mechanisms were given enhanced treatment by retaining them within the scope of the augmented programs and in the risk informed program for the applicable damage mechanisms.

In addition, all in-scope piping components, regardless of risk classification, will continue to receive Code-required pressure and leak testing, as part of the current ASME Section XI program. VT-2 visual examinations are scheduled in accordance with the station's pressure and leak test program, which remains unaffected by the RISI program.

The Quad Cites RISI evaluation included an evaluation of the impact of external events as part of the consequence evaluation in accordance with the EPRI Topical Report. In view of the large contributions that fires make to the current CDF and LERF results, a sensitivity evaluation was performed to determine whether elements selected on the basis of the internal events PRA would be impacted by the inclusion fires into the PRA used for consequence determination. This evaluation, which is included in the Tier 2 documentation for the RISI program (Reference 4), concluded that fire contributions to CDF and LERF do not impact the selection of RISI exams that were initially determined from the internal events PRA.

<u>Additional Examinations</u>

Since the RISI program may require examinations on a number of elements constructed to lesser pre-service inspection requirements, the program in all cases will determine through an engineering evaluation the root cause of any unacceptable flaw or relevant condition found during examination. The evaluation will include the applicable service conditions and degradation mechanisms to establish that the element(s) will still perform their intended safety

function during subsequent operation. Elements not meeting this requirement will be repaired or replaced.

The evaluation will include a determination of whether other elements in the segment or segments are subject to the same root cause conditions. Additional examinations will be performed on these elements up to a number equivalent to the number of elements required to be inspected on the segment or segments initially. If unacceptable flaws or relevant conditions are again found similar to the initial problem, the remaining elements identified as susceptible will be examined. No additional examinations will be performed if there are no additional elements identified as being susceptible to the same root cause conditions.

3.6 Program Relief Requests

In instances where a location may be found at the time of the examination that does not meet the >90% coverage requirement, the process outlined in the EPRI Topical Report will be followed.

ComEd has not yet completed its evaluation of existing relief requests to determine which can be withdrawn due to changes that occur from implementing the RISI program. Until this evaluation is completed, all existing relief requests remain in place.

3.7 Risk Impact Assessment

The RISI program has been conducted in accordance with Regulatory Guides 1.174 and 1.178, and the EPRI Topical Report, which require an evaluation to show that implementation of a risk informed inspection program would result in acceptably small changes, if any, in CDF and LERF.

The risk impact assessment performed in this RISI application included a qualitative evaluation as well as a comprehensive quantitative evaluation of the changes in CDF and LERF due to changes in the ISI program for each piping segment in the scope of the RISI evaluation. This is another enhancement that was made that goes well beyond the limited quantitative analyses that are needed to implement the methods described in the EPRI Topical Report.

Individual elements were evaluated for consequence and degradation mechanism and then assigned to a risk category and risk ranking as part of the risk characterization step. For the purposes of the risk impact evaluation, elements were combined into risk segments. As a result of this process, each risk segment has the same qualitative potential for pipe failure according to the potential applicable damage mechanisms and the same consequences as called for in the EPRI Topical Report. The risk segments were then grouped by system and the changes in risk for each risk segment were evaluated qualitatively by noting increases and decreases in the number of exams and for the potential for increases in the NDE probability of detection where the "inspection for cause" principle was applied. Then, each segment was quantified in terms of changes in failure frequency, rupture frequency, CDF, and LERF due to proposed changes in the risk informed inspection program.

Per Section 3.7.2 of EPRI TR-112657, the Markov piping reliability analysis method was used to estimate the change in risk due to adding and removing locations from the inspection program. The actual CCDP and CLERP values calculated for each element in the consequence assessment was used in the risk impact calculation. Realistic quantitative estimates of failure frequencies, rupture frequencies, and risk impacts were performed for all segments and elements within the scope of the RISI evaluation, in lieu of the qualitative analysis and bounding risk estimates that are permitted under most circumstances in the EPRI Topical Report.

The changes to the ISI program include changing the number and location of inspections within the risk segment, and in many cases improving the effectiveness of the inspection to account for the results of the RISI degradation mechanism assessment. For example, for locations subject to thermal fatigue, examinations are to be conducted on an expanded volume and are to be focused to enhance the probability of detection (POD) during the inspection process. For other damage mechanisms, this "inspection for cause" principle is also expected to favorably impact the POD.

Limits are imposed by the EPRI methodology (TR-112657) to ensure that the change in risk of implementing the RISI program meets the requirements of Regulatory Guides 1.174 and 1.178. The criteria established require that the cumulative increase in CDF and LERF be less than $1x10^{-7}$ and $1x10^{-8}$ per year per system, respectively. Meeting these limits is consistent with meeting Regulatory Guide 1.174 risk significant thresholds of $1x10^{-6}$ per year and $1x10^{-7}$ per year for changes in CDF and LERF for a full plant scope RISI application.

The technical basis for the Markov model input parameters that were used in this evaluation are documented in the Tier 2 documentation (Reference 4). These parameters include a set of failure rates and rupture frequencies for piping systems in General Electric BWR plants subject to several degradation mechanisms that were identified for these systems as part of the degradation mechanism assessment. The failure rates and rupture frequencies that were used in this evaluation are those developed in Table A-11 in EPRI TR-111880 (Reference 6).

Separate Markov calculations were performed for the change in CDF and the change in LERF. This calculation was performed so that pipe elements whose failure could create a potential containment failure or bypass concern were factored into the LERF evaluation. Due to the relatively high LERF to CDF ratios for these BWR Mark I reactor units, the change in LERF tended to be more limiting than the change in CDF evaluations when comparing the results to the EPRI RISI risk significance thresholds. Unlike previous applications of the EPRI methodology, realistic estimates of CDF and LERF contributions and changes in CDF and LERF due to all changes in the RISI program were quantified for all pipe elements, in addition to a qualitative evaluation that is part of the EPRI procedure.

The results of the risk impact assessment for each system at Quad Cities Unit 1 are summarized in Table 7 and key aspects are plotted in Figures 2 and 3 for comparison against the risk significant criteria established in the EPRI Topical Report. A similar set of results is presented in Table 8 and Figures 4 and 5 for Unit 2. As seen in these figures and tables, most of the systems evaluated across the two reactor units exhibited very small increases in CDF and LERF. In each case in which a risk increase was identified, the estimated increases in CDF and LERF

are much smaller than the risk acceptance criteria by a large margin. Each system was found to have a change in LERF that is less than or equal to 15% of the EPRI RISI risk significance threshold of $1x10^{-8}$/system-year, and a change in CDF that is less than 4.1% of the associated threshold of $1x10^{-7}$/system-year.

The total change in CDF and LERF due to the combined changes in the RISI program for the entire scope of Class 1 and 2 systems are very small in relation to Regulatory Guide 1.174 risk significance criteria.

As a sensitivity case, an evaluation was performed assuming that all NDE exams were removed from the ISI program, indicating that the EPRI RISI risk significance thresholds still would not be exceeded.

As indicated above, the risk impact evaluation has demonstrated that no significant risk impacts will occur from implementation of the RISI program for the entire scope of Class 1 and 2 piping that was included in this evaluation. This satisfies the risk significance criteria of Regulatory Guide 1.174 and the EPRI Topical Report (Reference 1).

Defense-In-Depth

The intent of the inspections mandated by ASME Section XI for piping welds is to identify conditions such as flaws or indications that may be precursors to leaks or ruptures in a system's pressure boundary. Currently, the process for picking inspection locations is based upon structural discontinuity and stress analysis results. As depicted in ASME White Paper 92-01-01 Rev. 1, "Evaluation of Inservice Inspection Requirements for Class 1, Category B-J Pressure Retaining Welds," this method has been ineffective in identifying leaks or failures. EPRI TR-112657 and ASME Code Case N-578-1 provide a more robust selection process founded on actual service experience with nuclear plant piping failure data.

This process has two key independent ingredients: (1) a determination of each location's susceptibility to degradation and (2) an independent assessment of the consequence of the piping failure. These two ingredients assure defense-in-depth is maintained. First, by evaluating a location's susceptibility to degradation, the likelihood of finding flaws or indications that may be precursors to leak or ruptures is increased. Secondly, the consequence assessment effort has a single failure criterion. As such, no matter how unlikely a failure scenario is, it is ranked High in the consequence assessment, and no lower than Medium in the risk assessment (i.e., Risk Category 4), if, as a result of the failure, there is no mitigative equipment available to respond to the event. In addition, the consequence assessment takes into account equipment reliability, with less credit given to less reliable equipment.

All locations within the reactor coolant pressure boundary will continue to receive a system pressure test and visual VT-2 examination as currently required by the Code regardless of its risk classification.

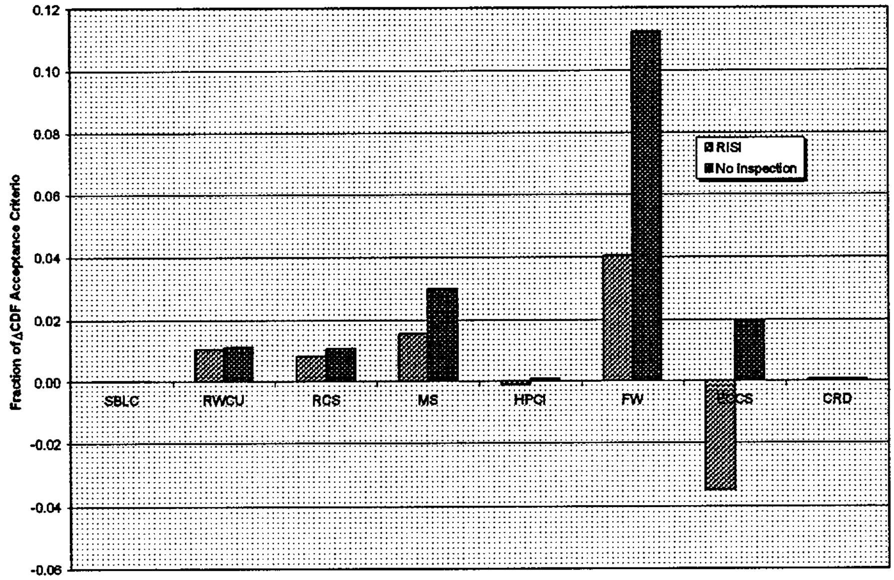

Figure 2

Change in Pipe Rupture CDF for Quad Cities Unit 1 Systems

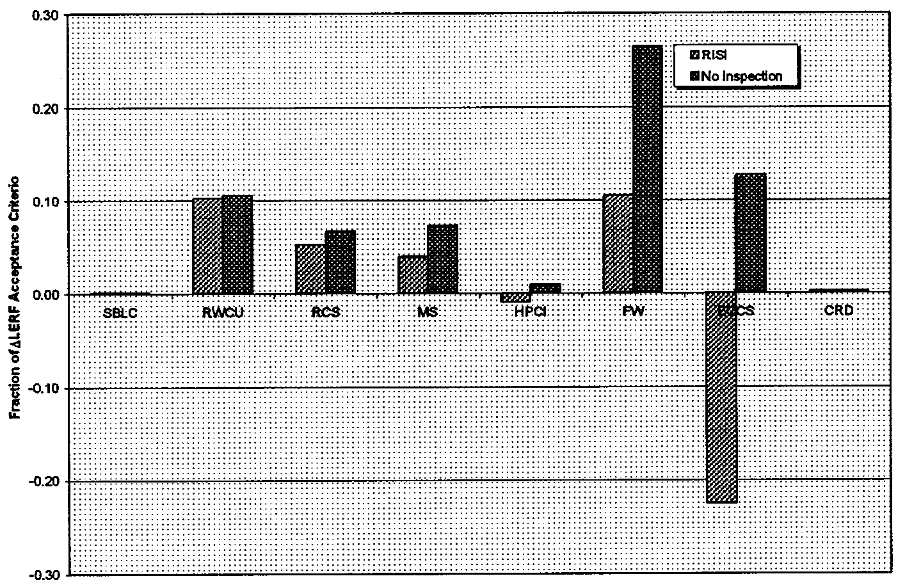

Figure 3

Change in Pipe Rupture LERF for Quad Cities Unit 1 Systems

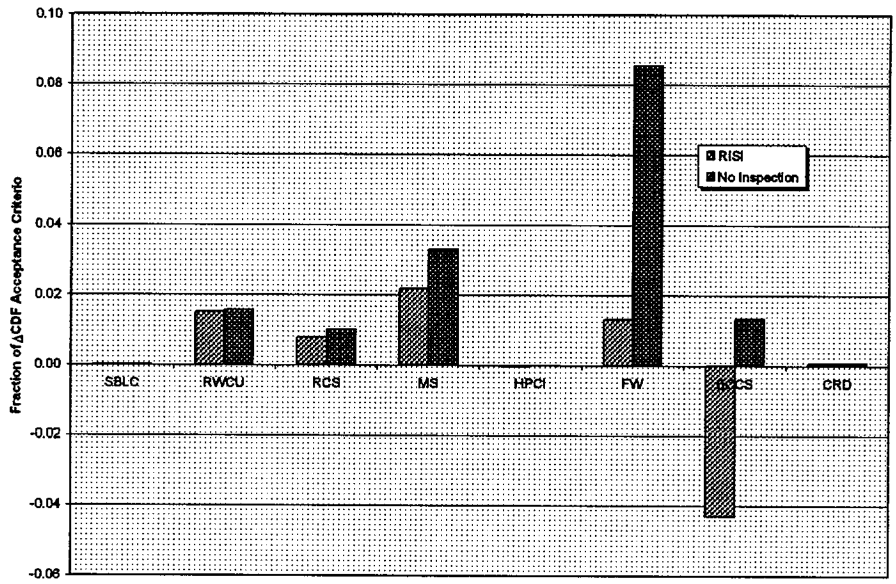

Figure 4
Change in Pipe Rupture CDF for Quad Cities Unit 2 Systems

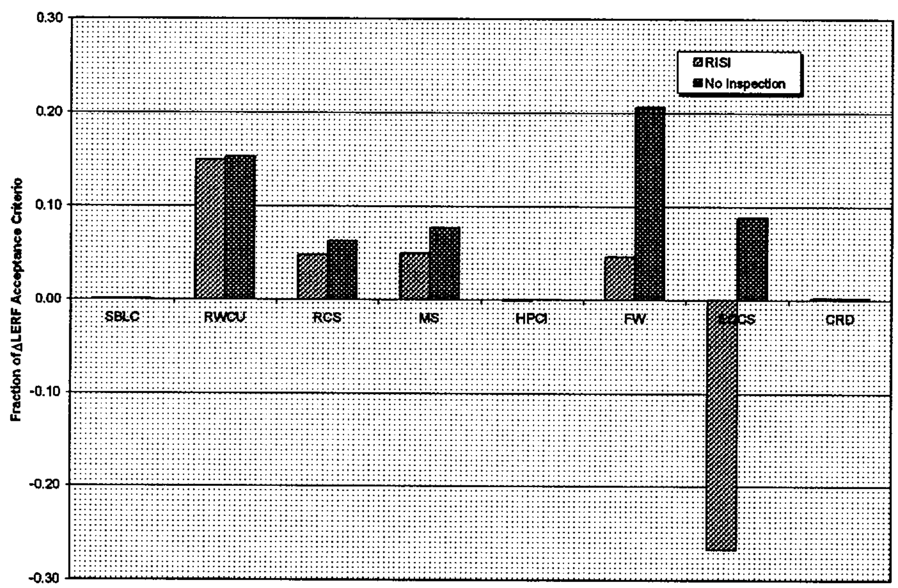

Figure 5
Change in Pipe Rupture LERF for Quad Cities Unit 2 Systems

4. IMPLEMENTATION AND MONITORING PROGRAM

Upon approval of the RISI program, procedures that comply with the guidelines described in EPRI RISI Topical Report will be prepared to implement and monitor the program. The new program will be integrated into the third period of the third inservice inspection interval for Quad Cities Units 1 and 2. No changes to the Updated Final Safety Analysis Report are necessary for program implementation.

The applicable aspects of the ASME Code not affected by this change are to be retained, such as inspection methods, acceptance guidelines, pressure testing, corrective measures, documentation requirements, and quality control requirements. Existing ASME Section XI program implementing procedures are to be retained and modified to address the RISI process, as appropriate.

The RISI program is a living program requiring feedback of new relevant information to ensure the appropriate identification of high safety significant piping locations. Such relevant information would include major updates to the Quad Cities Units 1 and 2 PRA models which could impact both the risk characterization and risk impact assessments, any new trends in service experience with piping systems at Quad Cities and across the industry, and new information on element accessibility that will be obtained as the risk informed inspections are implemented. As a minimum, risk ranking of piping segments and element selections will be reviewed and adjusted on an ASME ISI interval basis. In addition, changes may occur more frequently as directed by NRC Bulletin or Generic Letter requirements, or by industry and plant-specific service experience feedback.

5. PROPOSED ISI PROGRAM PLAN CHANGE

A comparison between the RISI program and 1989 ASME Section XI Code Edition program requirements for in-scope piping is provided in Table 5 and Table 6 for Unit 1 and Unit 2, respectively. The number of exams at Unit 1 is reduced from 192 Section XI program exams to 104 RISI program exams, a net reduction of 88 exams (46% reduction in number of exams). An additional 30 Section XI exams were also eliminated from the FAC and IGSCC augmented program welds for a total reduction of 127 exams compared to the 231 Section XI total (55% reduction). Unit 2 is reduced from 181 exams to 98 exams, a net reduction of 83 exams (46% reduction in number of exams). An additional 43 Section XI exams were also eliminated from the FAC and IGSCC augmented program welds for a total reduction of 126 exams compared to the 224 Section XI total (56% reduction). As shown in Tables 7 and 8, the total increase in CDF and LERF due to the net changes in number and location of inspections in all systems that were evaluated in this risk informed evaluation was found to be less than $1x10^{-8}$ per year, and $1x10^{-9}$ per year, respectively. These risk impacts are acceptably small in relation to the risk significance thresholds of the EPRI Topical Report and those in Regulatory Guide 1.174.

6. REFERENCES

1. EPRI, "Revised Risk-Informed Inservice Inspection Evaluation Procedure," Topical Report (TR-112657), Rev. B, December 1999.
2. ComEd Calculation QDC-0200-M-0803, CDF Results for Quad Cities Units 1 and 2.
3. ComEd Calculation QDC-(to be determined), LERF Results for Quad Cities Units 1 and 2.
4. ComEd Risk Informed Inservice Inspection Evaluation, Quad Cities Nuclear Power Plant Units 1 and 2 – Final Report, August 2000.
5. Not used.
6. T.J. Mikschl and K.N. Fleming, "Piping System Failure Rates and Rupture Frequencies for Use in Risk informed Inservice Inspection Applications," EPRI TR-111880, 1999, September 1999. *EPRI Licensed Material*
7. ASME Code Case N-578-1, "Risk-Informed Requirements for Class 1, 2, and 3 Piping, Method B, Section XI, Division 1.

Table 1
System Selection and Segment Definition for Unit 1 / Unit 2

System Description	Number of Segments
Main Steam (MS)	25 / 25
Reactor Core Isolation Cooling (RCIC)	2 / 2
Feedwater (FWA, FWB)	18 / 18
Reactor Recirculation System (RR)	41 / 42
Core Spray System (CSA, CSB)	38 / 40
High Pressure Coolant Injection (HPCI)	29 / 28
Shutdown Cooling (SDC)	4 / 4
Reactor Water Cleanup System (RWCU)	4 / 5
Residual Heat Removal Trains "A" and "B" (RHR, RHRA, RHRB)	85 / 86
Standby Liquid Control (SBLC)	1 / 1
Control Rod Drive and Scram Discharge Volume (CRD)	8 / 8
ECCS Common Suction – Torus Ring Header (ECCS)	2 / 3
Jet Pump Instrument Nozzles (JPI)	1 / 1
Reactor Pressure Vessel (RPV)	4 / 4
Total	262 / 267

NOTES: This table shows the number of pipe segments from each system that are Class 1 or Class 2 category B-J, B-F, C-F-1, C-F-2. The number of segments is shown for each unit.

Table 2
Failure Potential Assessment Summary for Unit 1 and Unit 2

	Thermal Fatigue		Stress Corrosion Cracking				Localized Corrosion			Flow Sensitive	
System	**TASCS**	**TT**	**IGSCC**	**TGSCC**	**ECSCC**	**PWSCC**	**MIC**	**PIT**	**CC**	**E-C**	**FAC**
CRD[1]											
ECCS[2]	X	X	X							X	
FW	X	X									X
HPCI / RCIC		X									
MS											
RCS[3]			X								
RWCU											
SBLC											

1. Includes scram discharge volume.
2. Includes CS, SDC, and RHR.
3. Includes reactor recirculation (RR), reactor pressure vessel (RPV), and jet pump instrument nozzles (JPI).

TASCS – thermal stratification, cycling and stripping, TT – thermal transients, IGSCC – intergranular stress corrosion cracking, TGSCC – transgranular stress corrosion cracking, ECSCC – external chloride stress corrosion cracking, PWSCC – primary water stress corrosion cracking, MIC – microbiologically influenced corrosion, PIT – pitting, CC – crevice corrosion, E-C – erosion-cavitation, FAC – flow accelerated corrosion

NOTE: This table shows the assessed failure mechanisms for each system. The RISI Program addresses the cumulative impact of all mechanisms that were identified in each system.

Table 3
Number of Elements (Welds) by Risk Category for Unit 1

System	High Risk[4]			Medium Risk[4]		Low Risk[4]	TOTAL
	Category 1	**Category 2**	**Category 3**	**Category 4**	**Category 5**	**Category 6 or 7**	**All Categories**
CRD[1]						53	53
ECCS[2]		184		156	44	202	586
FW	53		10			3	66
HPCI / RCIC				39		108	147
MS				122		8	130
RCS[3]		101		38	7	69	215
RWCU				26		36	62
SBLC						4	4
TOTAL	53	285	10	381	51	483	1263

1. Includes scram discharge volume.
2. Includes CS, SDC, and RHR.
3. Includes reactor recirculation (RR), reactor pressure vessel (RPV), and jet pump instrument nozzles (JPI).
4. See Figure 1 for definition of EPRI Risk Categories.

NOTE: This table shows the results of the Risk Categorization for Unit 1. The risk categories are defined in Figure 3-4 of EPRI TR-112657 (Reference 1).

Table 4
Number of Elements (Welds) by Risk Category for Unit 2

System	High Risk[4]			Medium Risk[4]		Low Risk[4]	TOTAL
	Category 1	Category 2	Category 3	Category 4	Category 5	Category 6 or 7	All Categories
CRD[1]						53	53
ECCS[2]		179		150	49	202	580
FW	51		9			3	63
HPCI / RCIC				23		128	151
MS				118		8	126
RCS[3]		105		39	7	64	215
RWCU				28		39	67
SBLC						4	4
TOTAL	51	284	9	358	56	501	1259

1. Includes scram discharge volume.
2. Includes CS, SDC, and RHR.
3. Includes reactor recirculation (RR), reactor pressure vessel (RPV), and jet pump instrument nozzles (JPI).
4. See Figure 1 for definition of EPRI Risk Categories.

NOTE: This table shows the results of the Risk Categorization for Unit 2. The risk categories are defined in Figure 3-4 of EPRI TR-112657 (Reference 1). The minor differences are due to slight differences in the number of welds in these systems.

Table 5
Number of Inspections by Risk Category for Unit 1

	High Risk[4]						**Medium Risk[4]**				**Low Risk[4]**		**All Risk Categories**	
	Category 1		**Category 2**		**Category 3**		**Category 4**		**Category 5**		**Category 6 or 7**			
System	**Sec. XI**	**RISI**	**Sec. XI**	**RISI**	**Sec. XI**	**RISI**	**Sec. XI**	**RISI**	**Sec. XI**	**RISI**	**Sec. XI**	**RISI**	**Sec. XI**	**RISI**
CRD[1]											5	0	5	0
ECCS[2]			29	47			19	19	9	6	16	0	73	72
FW	10	5			0	1							10	6
HPCI / RCIC							2	5			13	0	15	5
MS							33	13			0	0	33	13
RCS[3]			0	0			19	5	0	0	19	0	38	5
RWCU							8	3			8	0	16	3
SBLC											2	0	2	0
TOTAL	10	5	29	47	0	1	81	45	9	6	63	0	192	104

1. Includes scram discharge volume.
2. Includes CS, SDC, and RHR.
3. Includes reactor recirculation (RR), reactor pressure vessel (RPV), and jet pump instrument nozzles (JPI).
4. See Figure 1 for definition of EPRI RISI risk categories.

NOTE: This table provides a comparison of the RISI element selection to the original ASME Section XI program. The total number of inspections is significantly lower for the RISI program. Some RISI inspection locations are new when compared to the Section XI program, i.e., they were previously not addressed.

Table 6
Number of Inspections by Risk Category for Unit 2

System	High Risk[4]						Medium Risk[4]				Low Risk[4]		All Risk Categories	
	Category 1		Category 2		Category 3		Category 4		Category 5		Category 6 or 7			
	Sec. XI	RISI	Sec. XI	RISI	Sec. XI	RISI	Sec. XI	RISI	Sec. XI	RISI	Sec. XI	RISI	Sec. XI	RISI
CRD[1]											5	0	5	0
ECCS[2]			28	45			18	18	7	6	12	0	65	69
FW	8	5			0	1							8	6
HPCI / RCIC							1	3			13	0	14	3
MS							32	12			1	0	33	12
RCS[3]			0	0			18	5			19	0	37	5
RWCU							8	3			9	0	17	3
SBLC											2	0	2	0
TOTAL	8	5	28	45	0	1	77	41	7	6	61	0	181	98

1. Includes scram discharge volume.
2. Includes CS, SDC, and RHR.
3. Includes reactor recirculation (RR), reactor pressure vessel (RPV), and jet pump instrument nozzles (JPI).
4. See Figure 1 for definition of EPRI RISI Risk Categories.

NOTE: This table provides the same information as Table 5 for Unit 2.

Table 7
Impact of RISI and No Inspections on CDF and LERF Due to Pipe Ruptures for Quad Cities Unit 1 Systems

System	System CDF Events/Reactor-Year			Δ CDF Events/Reactor-Year			Δ LERF Events/Reactor-Year		
	Section XI	RISI	No Inspection	RISI	No Inspection	Acceptance Criterion	RISI	No Inspection	Acceptance Criterion
SBLC	1.84E-11	2.57E-11	2.57E-11	7.25E-12	7.25E-12	<1.00E-07	6.14E-12	6.14E-12	<1.00E-08
RWCU	2.42E-09	3.48E-09	3.53E-09	1.05E-09	1.11E-09	<1.00E-07	1.03E-09	1.06E-09	<1.00E-08
RCS[3]	1.20E-08	1.29E-08	1.31E-08	8.35E-10	1.08E-09	<1.00E-07	5.22E-10	6.61E-10	<1.00E-08
MS	1.80E-08	1.96E-08	2.10E-08	1.55E-09	2.99E-09	<1.00E-07	3.87E-10	7.21E-10	<1.00E-08
HPCI[4]	5.90E-10	4.97E-10	6.87E-10	-9.36E-11	9.62E-11	<1.00E-07	-9.36E-11	9.62E-11	<1.00E-08
FW	9.47E-08	9.87E-08	1.06E-07	4.04E-09	1.13E-08	<1.00E-07	1.06E-09	2.65E-09	<1.00E-08
ECCS[2]	1.28E-08	9.33E-09	1.48E-08	-3.49E-09	1.95E-09	<1.00E-07	-2.25E-09	1.27E-09	<1.00E-08
CRD[1]	1.29E-09	1.37E-09	1.37E-09	7.29E-11	7.29E-11	<1.00E-07	2.43E-11	2.43E-11	<1.00E-08
Total	1.42E-07	1.46E-07	1.60E-07	3.97E-09	1.86E-08	<1.00E-06	6.76E-10	6.49E-09	<1.00E-07

NOTES:

1. Includes scram discharge volume.
2. Includes CS, SDC, and RHR.
3. Includes reactor recirculation (RR), reactor pressure vessel (RPV), and jet pump instrument nozzles (JPI).
4. Includes RCIC.

Table 8

Impact of RISI and No Inspections on CDF and LERF due to Pipe Ruptures for Quad Cities Unit 2 Systems

System	System CDF Events/Reactor-Year			Δ CDF Events/Reactor-Year			Δ LERF Events/Reactor-Year		
	Section XI	RISI	No Inspection	RISI	No Inspection	Acceptance Criterion	RISI	No Inspection	Acceptance Criterion
SBLC	1.84E-11	2.57E-11	2.57E-11	7.25E-12	7.25E-12	<1.00E-07	6.14E-12	6.14E-12	<1.00E-08
RWCU	2.82E-09	4.33E-09	4.39E-09	1.51E-09	1.57E-09	<1.00E-07	1.50E-09	1.53E-09	<1.00E-08
RCS[3]	1.23E-08	1.31E-08	1.34E-08	7.77E-10	1.02E-09	<1.00E-07	4.87E-10	6.25E-10	<1.00E-08
MS	1.53E-08	1.75E-08	1.86E-08	2.18E-09	3.30E-09	<1.00E-07	5.05E-10	7.74E-10	<1.00E-08
HPCI[4]	4.30E-10	3.84E-10	4.32E-10	-4.57E-11	1.78E-12	<1.00E-07	-7.96E-12	1.58E-12	<1.00E-08
FW	1.01E-07	1.02E-07	1.10E-07	1.32E-09	8.53E-09	<1.00E-07	4.75E-10	2.07E-09	<1.00E-08
ECCS[2]	1.22E-08	7.95E-09	1.36E-08	-4.30E-09	1.34E-09	<1.00E-07	-2.67E-09	8.91E-10	<1.00E-08
CRD[1]	1.29E-09	1.37E-09	1.37E-09	7.29E-11	7.29E-11	<1.00E-07	2.43E-11	2.43E-11	<1.00E-08
Total	2.91E-07	2.94E-07	3.23E-07	3.05E-09	3.17E-08	<1.00E-06	4.66E-10	7.50E-09	<1.00E-07

NOTES:
1. Includes scram discharge volume.
2. Includes CS, SDC, and RHR.
3. Includes reactor recirculation (RR), reactor pressure vessel (RPV), and jet pump instrument nozzles (JPI).
4. Includes RCIC.