F

ALTERNATE SSLR SURVEILLANCE CAPSULE WITHDRAWAL SCHEDULE

This appendix provides an SSLR Capsule Irradiation Withdrawal Schedule for the Supplemental Second License Renewal (SSLR) Surveillance Capsule Holder that is an alternate to those withdrawal schedule scenarios defined in Section 8. This alternate withdrawal schedule revises the total irradiation period from [ ]

Background

This report provides a plan and supporting technical basis to extend the current BWRVIP Integrated Surveillance Program (ISP) through the SLR period for the U.S. BWR fleet. The Nuclear Regulatory Commission (NRC) reviewed and approved the plan via Safety Evaluation (SE) issued in November 2020 [F-1]. There were no limitations or restrictions in the NRC SE.

As described in the body of this report, the plan for extension of the ISP relies upon the assembling of previously tested Charpy V-Notch (CVN) specimen halves and machining them into inserts that will, after further irradiation, be reconstituted into new CVN specimens and tested at the end of the SSLR irradiation period. The plan calls for assembling the inserts into packets that are arranged in three capsules (or groups) to be attached to a single SSLR surveillance capsule holder. The holder is to be attached to the outer diameter (OD) surface of the core shroud in a host plant to receive the needed "catch-up" fluence"[1]. Groups 1 and 2 require much less catch-up fluence than does Group 3.

Basis for Alternate Withdrawal Schedule

At the time the withdrawal schedules in Section 8 were developed, a host plant had not been selected, although scoping studies had been completed of some potential host plants to assess the neutron flux that could be attained at the core shroud OD surface (see Section 6). The results of these studies provided a basis for estimating the range of times each of the groups would potentially need to remain in the host plant to receive the needed catch-up fluence. As the host plant had not been selected, detailed plant unique neutron transport calculations had not yet been completed to project accumulated fluence over the planned SSLR irradiation period. As discussed in Section 4.4, there was a further constraint limiting the maximum neutron flux to which the CVN specimen halves could be exposed to [ ]

[ ]

[1] The "catch-up" fluence is the additional fluence necessary to achieve the 80 year target fluence.

[2] Fluence is expressed in terms of n/cm^2 with E>1 MeV.

[ ]

Section 8 provides a range of irradiation periods for each of the three capsules (groups) based on their required catch-up fluence. These estimates of irradiation period assumed a constant minimum and maximum flux that could be attained. The minimum flux was arbitrarily chosen such that, for the limiting capsule (Group 3), the required catch-up fluence could be attained in a 10-year period. The maximum flux was set at the maximum allowed value [ ]

Figures F-1 through F-6 show the original license end dates, as well as the first and potential second license renewal periods of extended operation for each U.S. BWR (note that although Pilgrim and Duane Arnold are shown in these figures, these plants have permanently ceased operations and do not require SSLR test data). Figures F-1, F-2 and F-3 also show the range (minimum and maximum) of potential irradiation periods for each of the three SSLR capsules (groups), respectively as documented in Section 8.

[ ]

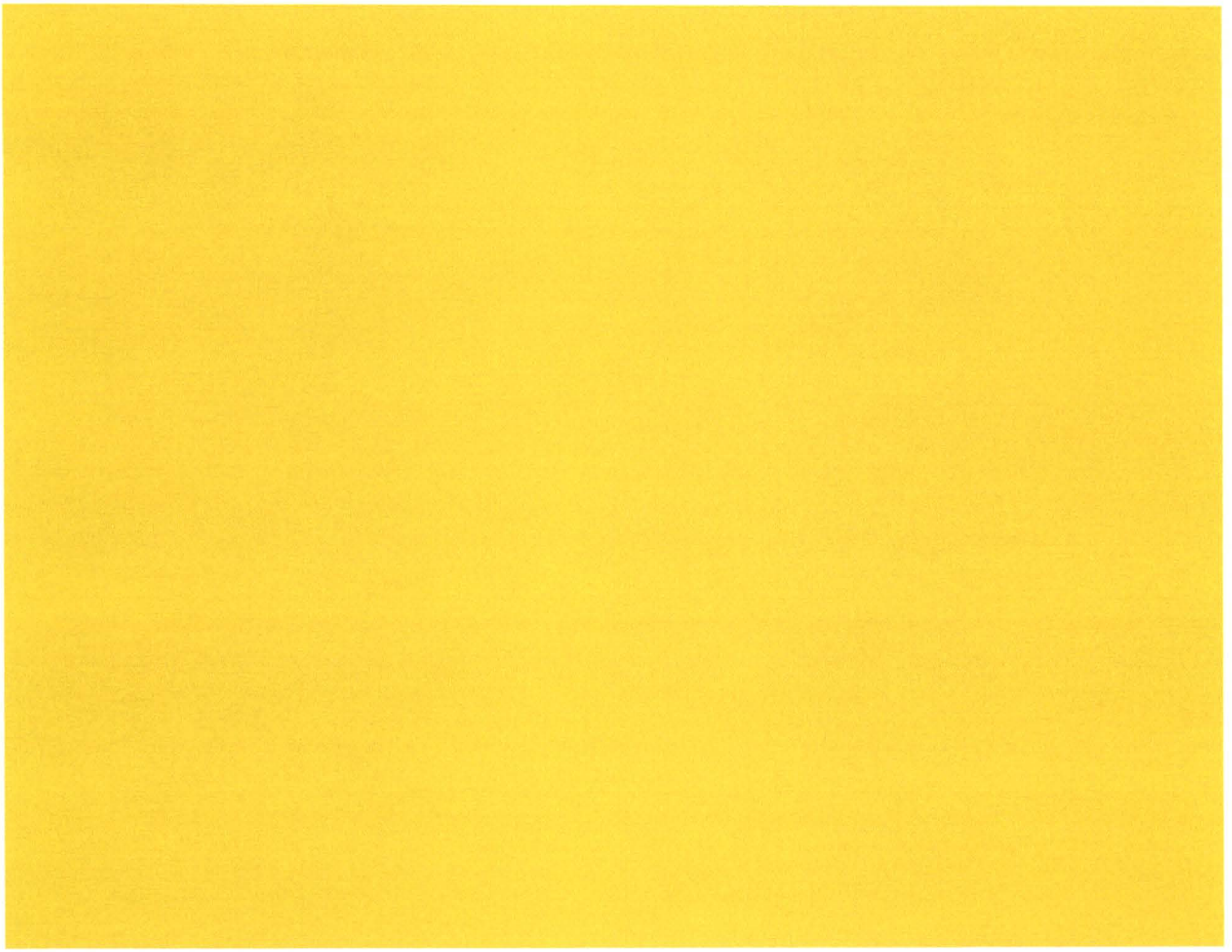


Figure F-1 Range of Irradiation Periods for Group 1 (Section 8)

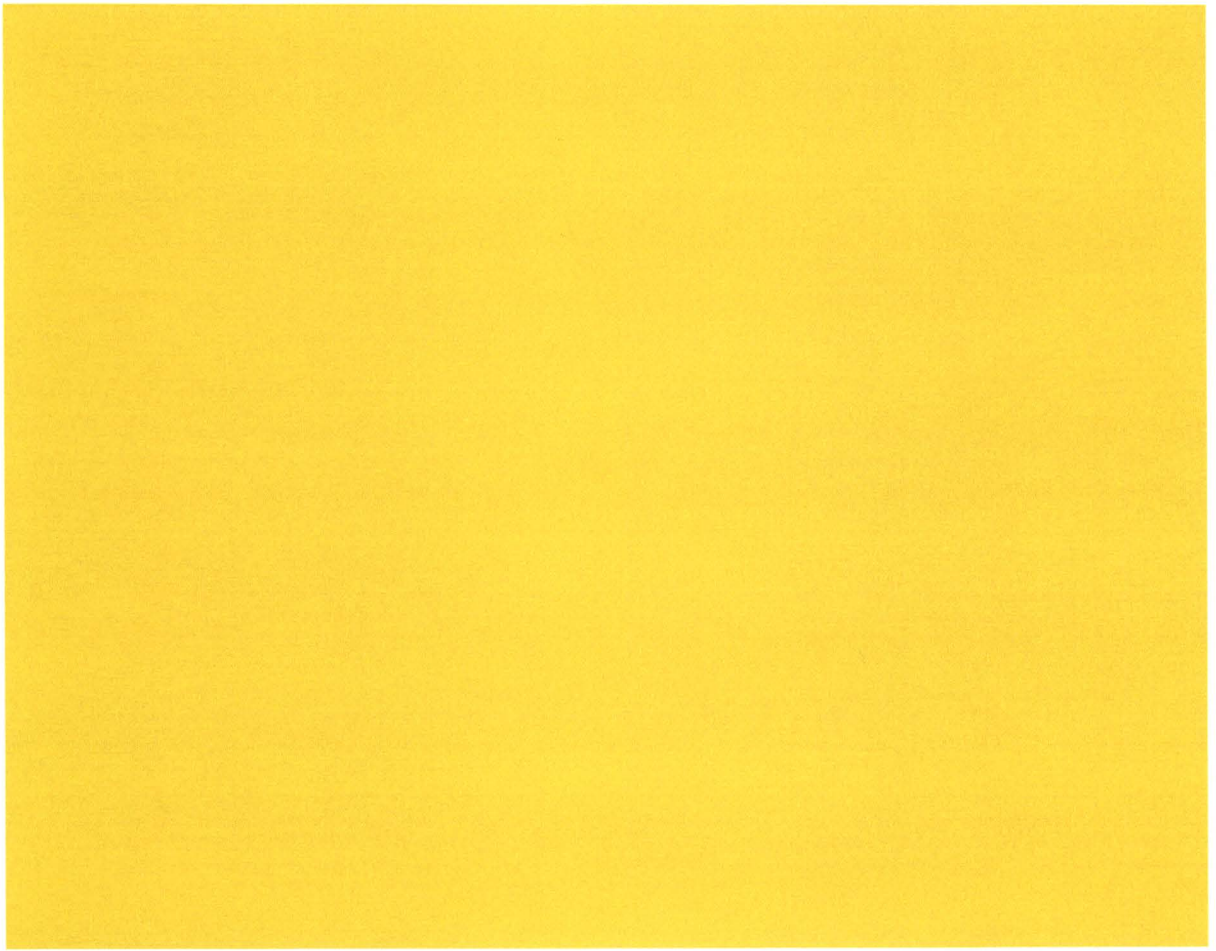


Figure F-2 Range of Irradiation Periods for Group 2 (Section 8)

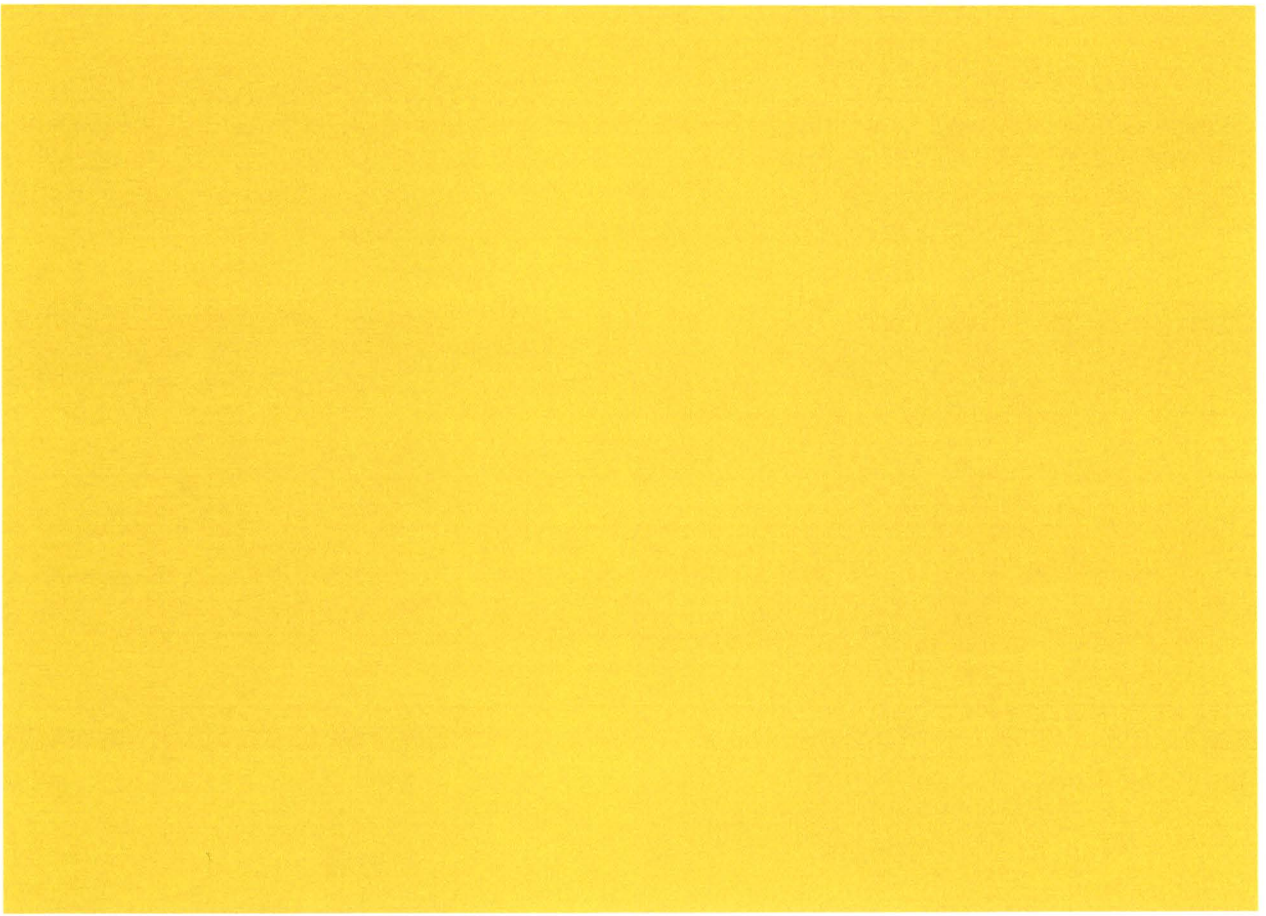


Figure F-3 Range of Irradiation Periods for Group 3 (Section 8)

Figures F-4, F-5 and F-6 show the irradiation periods for the Group 1, 2, and 3 capsules, respectively, associated with the alternate withdrawal schedule. [ ]

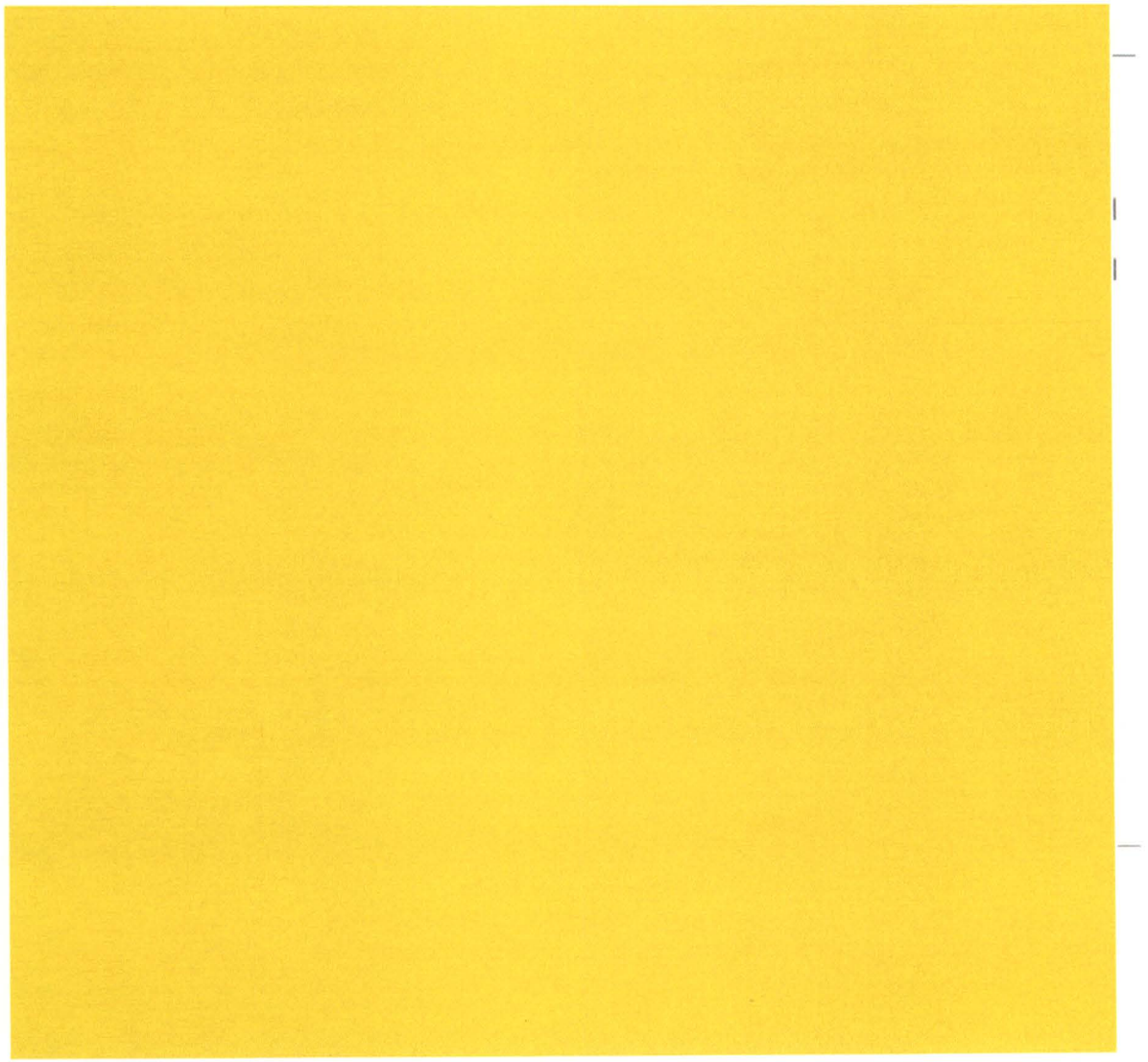


Figure F-4 Alternate Irradiation Period for Group 1

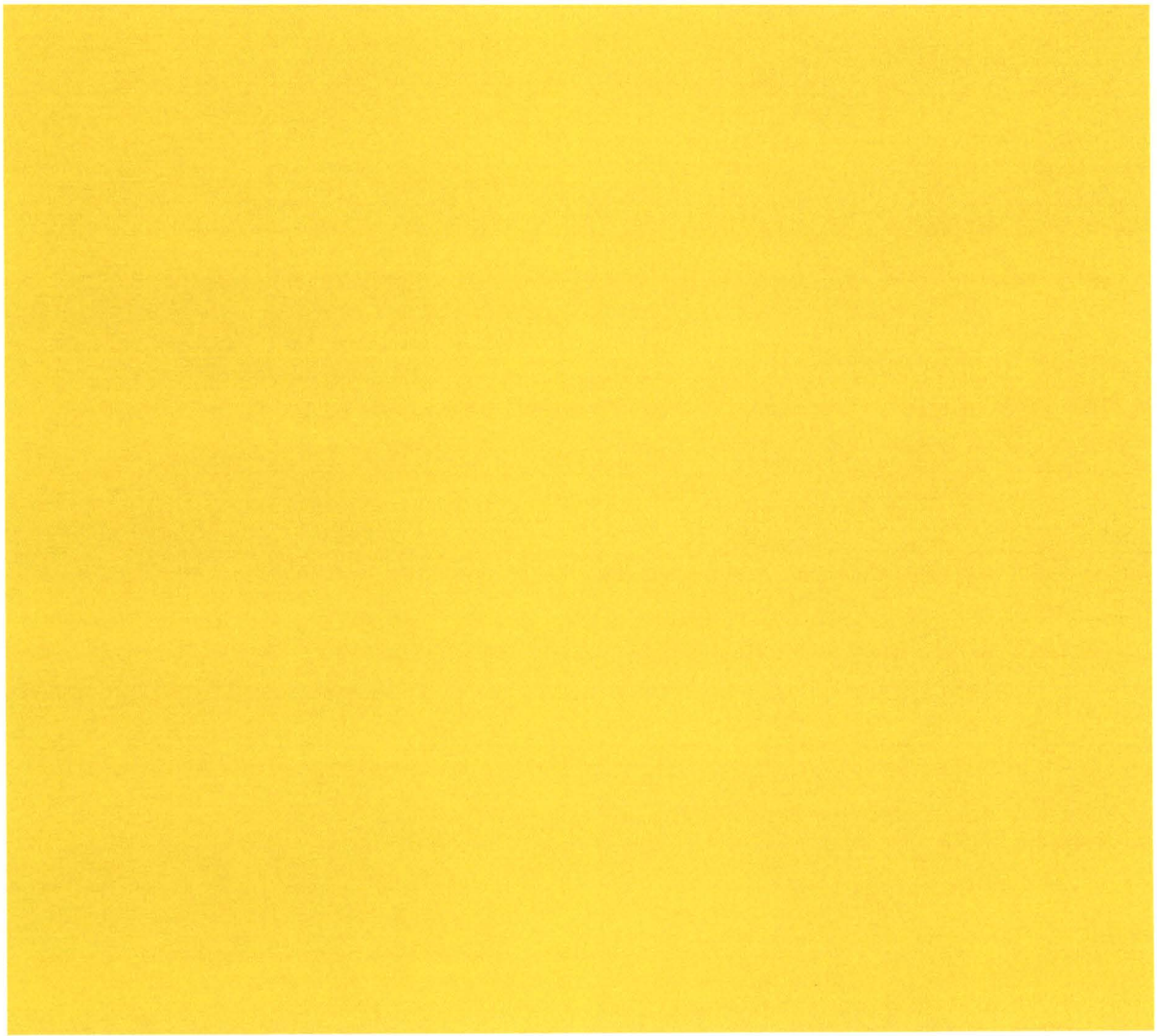


Figure F-5 Alternate Irradiation Period for Group 2

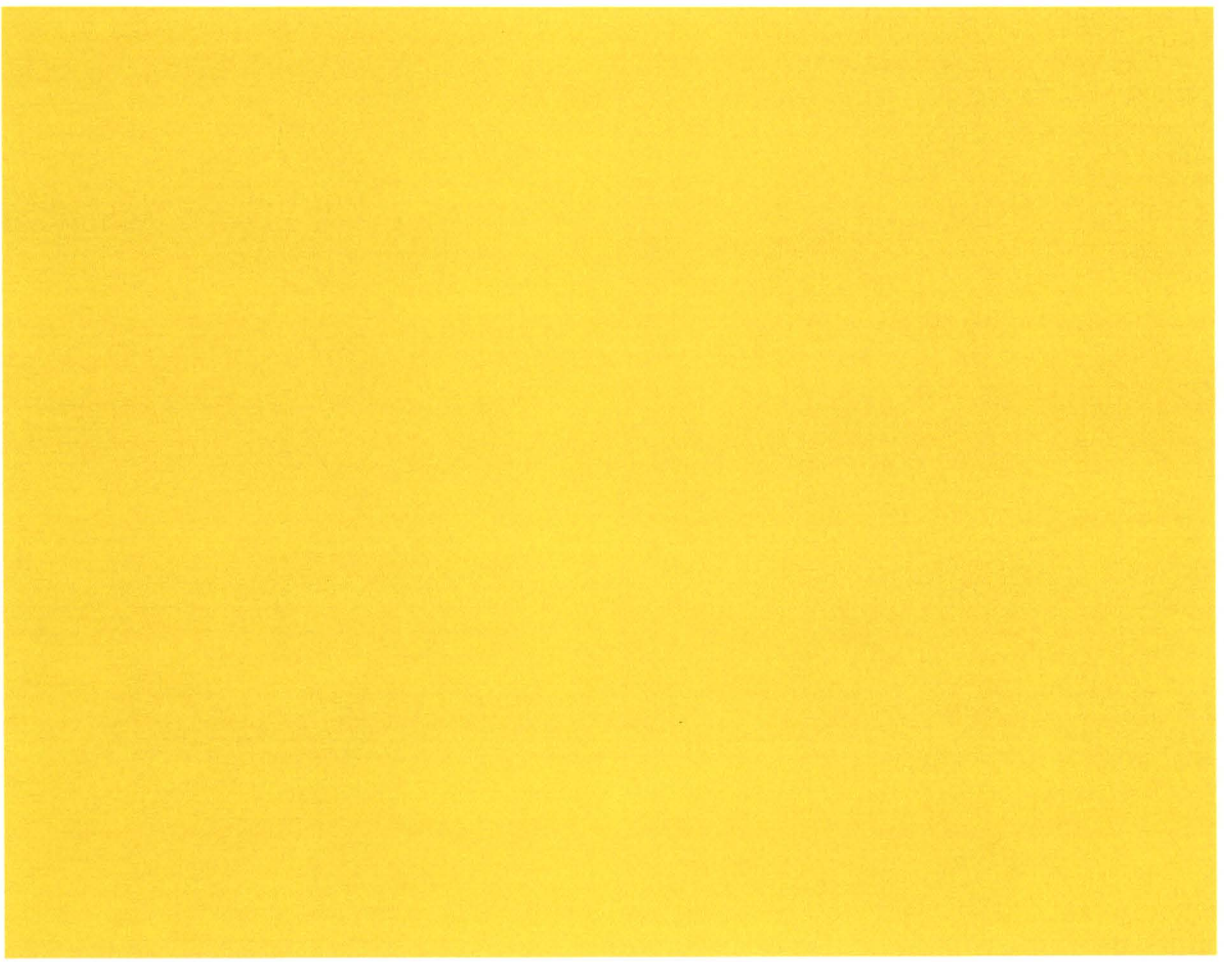


Figure F-6 Alternate Irradiation Period for Group 3

[
]

Table F-1 summarizes the results of detailed neutron transport calculations [F-2] conducted using the RAMA Code [F-3] to estimate the minimum and maximum fluence that is expected at each capsule (group) location for [

]

Table F-1 Minimum and Maximum Single Fuel Cycle Fluence for Host Plant Peach Bottom Unit 3 (w/o Uncertainty)

[

]

Tables F-2 through F-4 present the catch-up and total projected accumulated fluence values for the entire [ ]irradiation period at the maximum end of the uncertainty range for each material in capsules (groups) 1, 2 and 3, respectively. Note that the highest total accumulated fluence for any material is[ ]

Table F-2 Group 1 Capsule Fluence (12 Years at Maximum Projected Exposure)

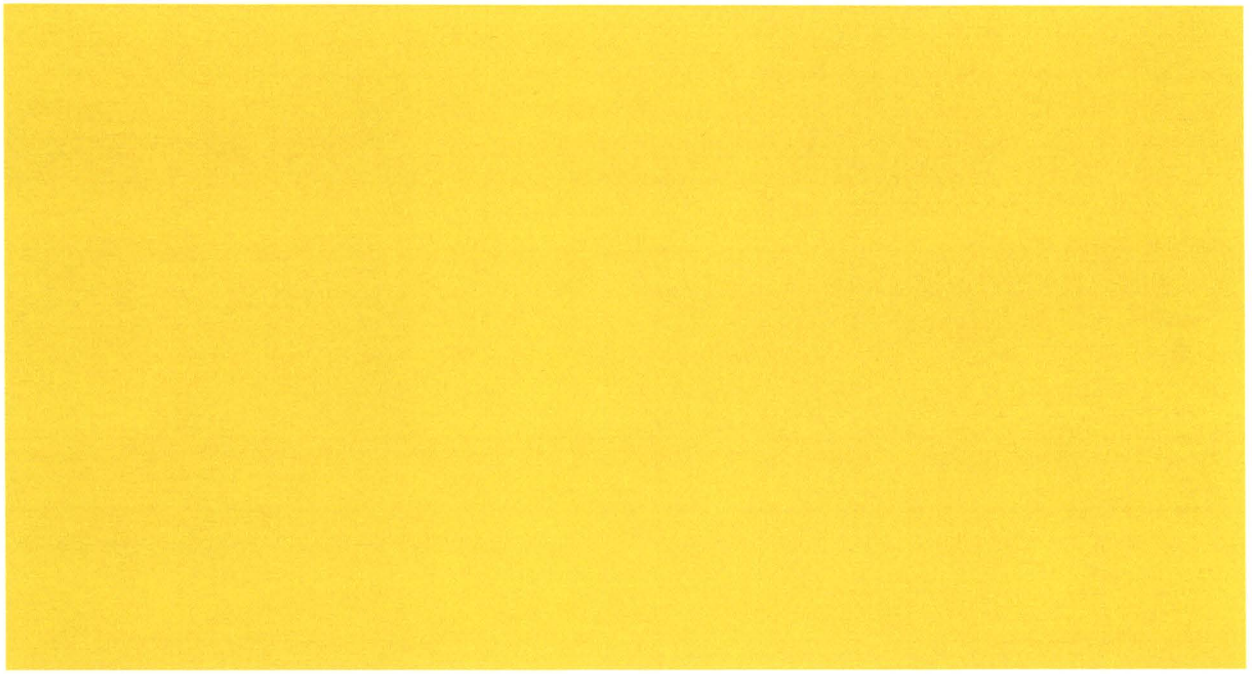


Table F-3 Group 2 Capsule Fluence (12 Years at Maximum Projected Exposure)

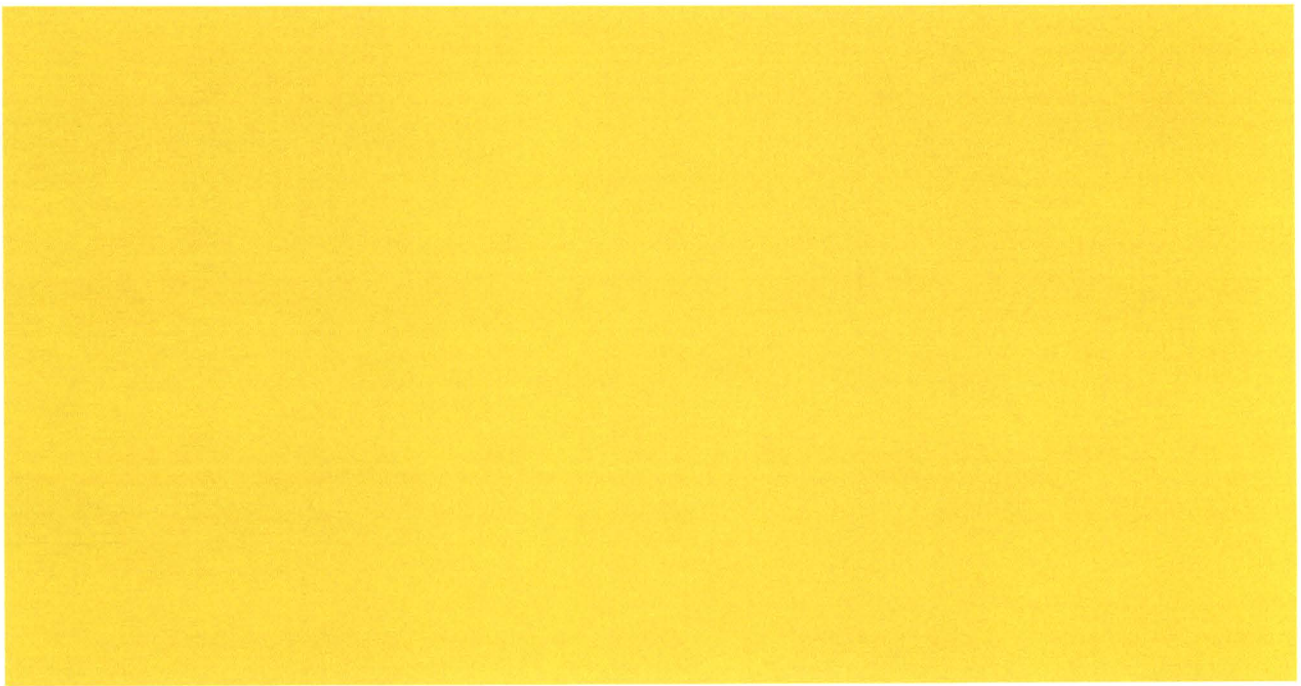
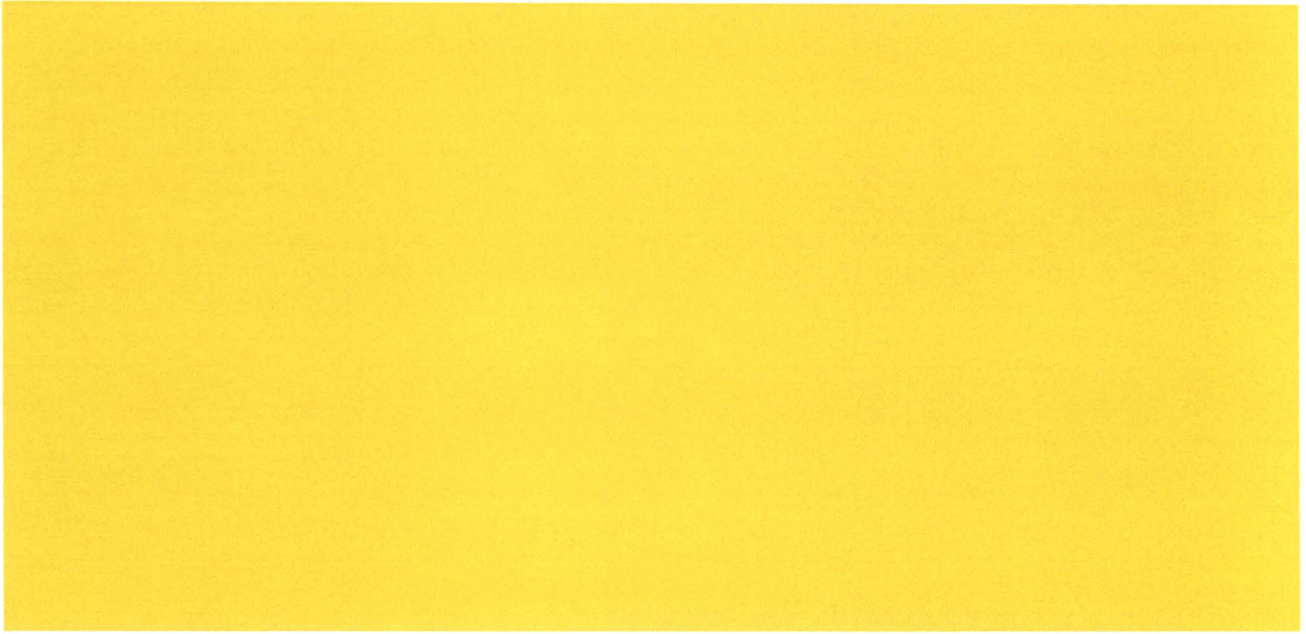


Table F-4 Group 3 Capsule Fluence (12 Years at Maximum Projected Exposure)



Tables F-5 through F-7, compare the catch-up and total projected accumulated fluence values for the entire 12-year irradiation period to the target total fluence values for each material in capsules (groups) 1, 2 and 3, respectively. Note that the minimum expected total accumulated fluence values exceed the needed values by at least [ ] for all materials.

Table F-5 Group 1 Capsule Fluence (12 Years at Minimum Projected Exposure)

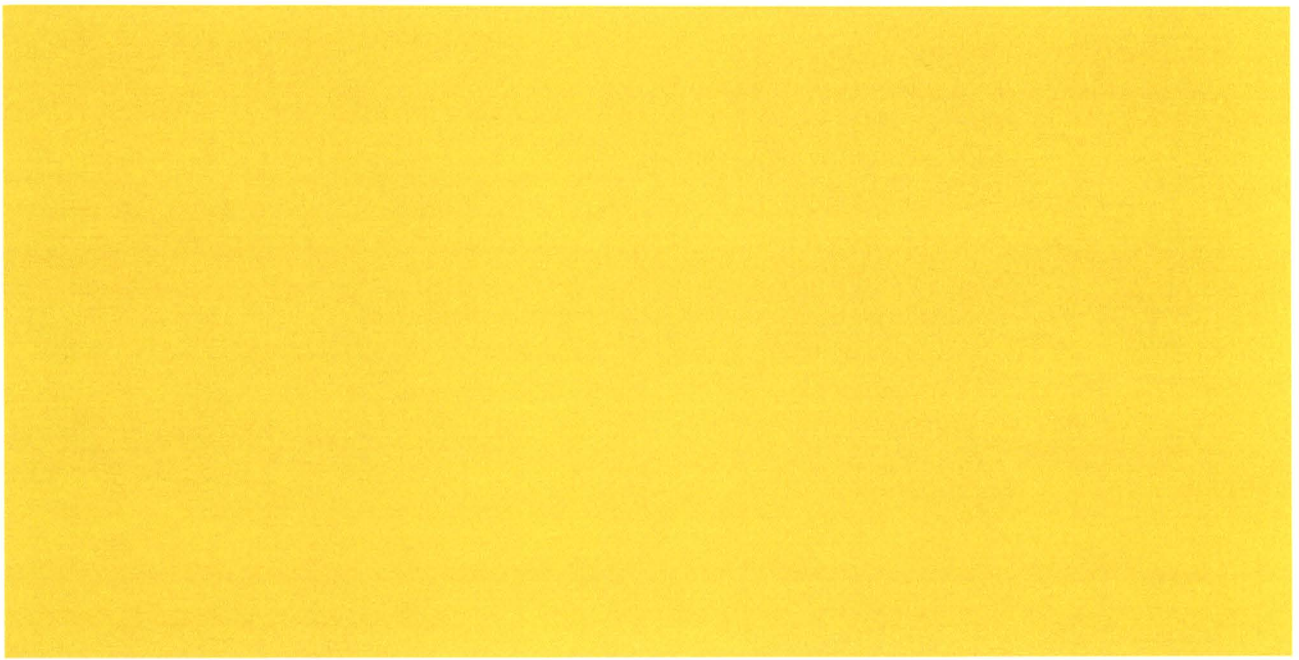


Table F-6 Group 2 Capsule Fluence (12 Years at Minimum Projected Exposure)

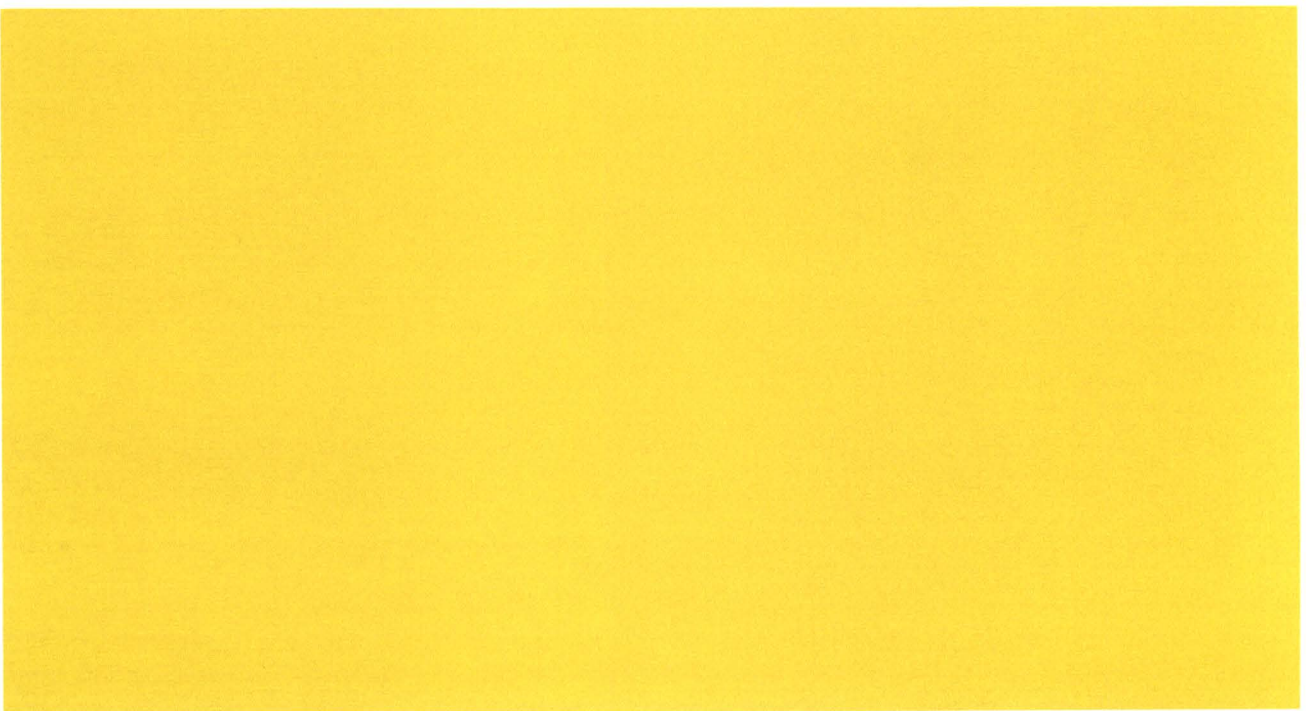


Table F-7 Group 3 Capsule Fluence (12 Years at Minimum Projected Exposure)

[redacted]

[redacted]

Summary

This report describes the plan for extending the BWRVIP ISP through a Second License Renewal period of extended operation for all U. S. BWR units. The plan involves mounting a single SSLR surveillance capsule holder that contains three capsules of previously irradiated CVN test specimen halves (inserts) on the OD surface of the core shroud. The capsules will receive the needed catch-up fluence to reach an 80-year life. Section 8 includes a range of potential irradiation periods for each of the three SSLR capsules (groups). At the time the irradiation periods in Section 8 were developed, only scoping analysis had been completed to assess potential neutron flux levels that could be attained at the core shroud OD surface for several potential host plants. [redacted]

[redacted]

Potential Revision to the Alternate SSLR Capsule Withdrawal Schedule

Under certain circumstances (e.g., unexpected extended outage durations in the Host plant or operation at reduced power for an extended period) it may be necessary to revise the withdrawal schedule so that the Group 3 capsule acquires the required total accumulated fluence. Under these circumstances, the withdrawal of the capsules and holder will be deferred by an amount of time commensurate with the impact and aligning with scheduled plant outages. The BWRVIP will notify NRC of any changes to the withdrawal schedule in a timely manner.

References

F-1 Final Safety Evaluation by the Office of Nuclear Reactor Regulation Electric Power Research Institute Topical Report BWRVIP-321: Boiling Water Reactor Vessel and Internals Project "Plan for Extension of the BWR Integrated Surveillance Program (ISP) Through the Second License Renewal (SLR)," November 2020. ADAMS ML20300A309.

F-2 Transware Technical Report: EPRI-2021-14-02, Revision 1, Supplemental Subsequent License Renewal Capsule Neutron Flux Predictions for Peach Bottom Atomic Power Station Unit 3

F-3 BWRVIP-126, Revision 2: BWR Vessel and Internals Project: RAMA Fluence Methodology, Version 1.2 Users' Manual. EPRI, Palo Alto CA:2010. 1020240

F-4 U. S. NRC TLR-RES/DE/CIB-2019-2 "Assessment of the Continued Adequacy of Revision 2 of Regulatory Guide 1.99 Technical Letter Report".

F-5 U.S. NRC Regulatory Guide 1.99, Revision 2, "Radiation Embrittlement of Reactor Vessel Materials," May 1999.

1
INTRODUCTION

Operating nuclear power plants in the U.S must meet the requirements of 10CFR50 Appendix H [1]. Appendix H requires that reactor vessels which will exceed a neutron fluence of 1 x 10^{17} n/cm^2 (E >1 MeV[1]) by the end of license (EOL) have a material surveillance program in order to monitor changes in the fracture toughness properties which result from exposure to neutron irradiation and the thermal environment. Fracture toughness test data are obtained from material specimens exposed in surveillance capsules, which are withdrawn periodically from the reactor pressure vessel (RPV). The data obtained from this material surveillance program are then used to demonstrate the vessel continues to meet the fracture toughness requirements of 10CFR50 Appendix G [2]. Of significance for boiling water reactors (BWRs), Appendix G provides the procedures by which the operating pressure-temperature (P-T) limit curves and leak test temperature are determined.

Each U.S. BWR was designed and built with a surveillance capsule program and until 2002, compliance with 10CFR50 Appendix H was demonstrated by each plant individually. Since 2002, the U.S. BWR fleet has relied on an integrated surveillance program (ISP) to provide fracture toughness data for RPV materials in lieu of plant specific programs [3]. The ISP uses select plant surveillance capsules to provide valuable data to support the ISP and to satisfy the requirements of 10CFR50 Appendix H. The current ISP, developed and managed by the Boiling Water Reactor Vessel and Internals Project (BWRVIP), was designed to support the surveillance needs of the BWR fleet through 60 years of operation (EOLE), which was the maximum license period foreseen at the time of its development [4]. Plants are currently evaluating the potential for a second license renewal (SLR) which would allow for operation to 80 years of plant life.

Recognizing the need to satisfy the requirements of 10CFR50 Appendix H in the SLR period, while also recognizing the limitations of the existing ISP for meeting those requirements, options for the SLR period were evaluated. This report incorporates the findings of those evaluations and provides a comprehensive program plan for extension of the ISP for the SLR period.

Revision 1 of this report incorporates an alternative surveillance capsule withdrawal schedule for the SSLR capsules. See Section 8 and Appendix F for details.

1.1 Implementation Requirements

The results documented in this report will be utilized by the BWRVIP ISP and by individual utilities to demonstrate compliance with 10CFR50 Appendix H Reactor Vessel Material Surveillance Program Requirements. Therefore, the implementation requirements of 10CFR50 Appendix H govern and the implementation requirements of Nuclear Energy Institute (NEI) 03-08, Guideline for the Management of Materials Issues, are not applicable.

[1] Neutron fluence and flux values identified in this report are for E>1MeV unless stated otherwise

Schedule for SSLR Capsule Insertion, Withdrawal, and Testing
Group 3 Plates and Welds

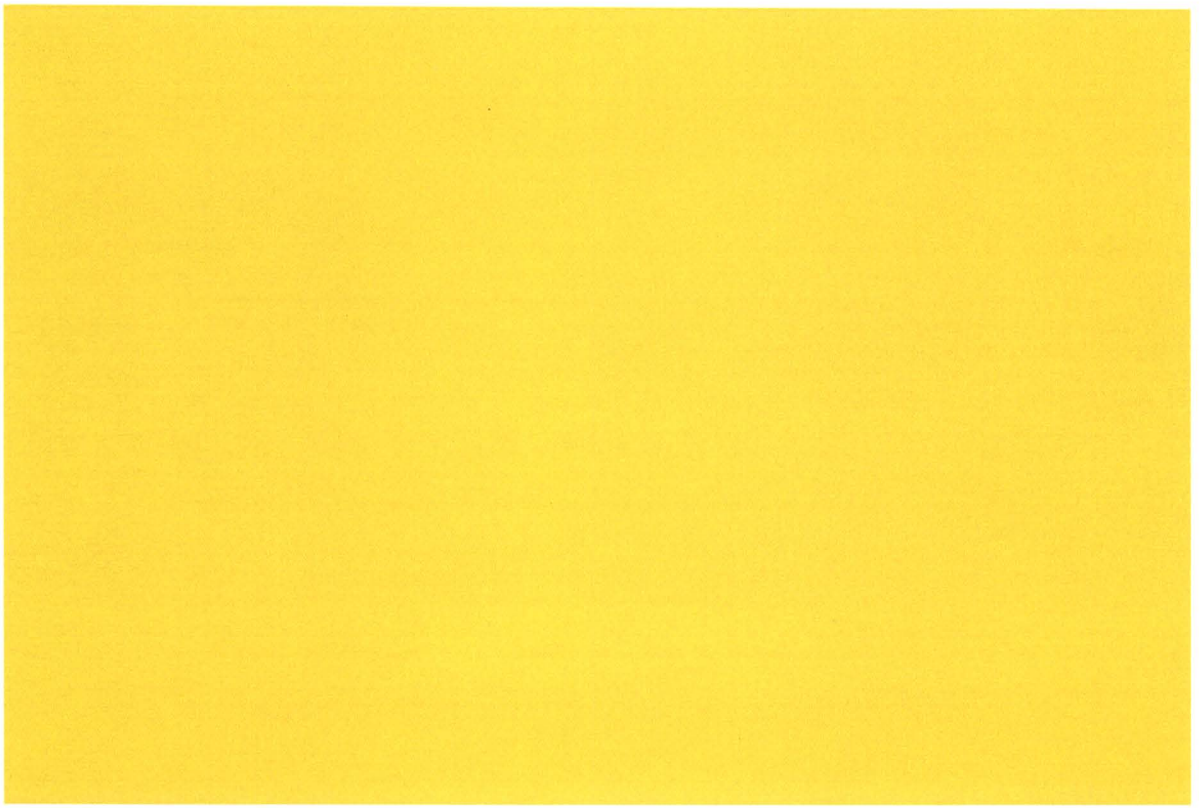


Figure 8-3
Schedule for Group 3 SSLR capsule irradiation compared with license dates for BWRs represented by the Group 3 capsule materials

8.1 Alternate SSLR Surveillance Capsule Withdrawal Schedule

Based on the selection of Peach Bottom Unit 3 as the Host plant, and completion of plant unique transport calculations, an alternate SSLR Surveillance Capsule withdrawal schedule has been developed. This alternate withdrawal schedule and associated technical basis are presented in Appendix F.