

April 17, 2001

Mr. Harold W. Keiser
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SUBJECT: HOPE CREEK GENERATING STATION - SITE-SPECIFIC WORKSHEETS FOR
USE IN THE NUCLEAR REGULATORY COMMISSION'S SIGNIFICANCE
DETERMINATION PROCESS (TAC NO. MA6544)

Dear Mr. Keiser:

Enclosed please find the Risk-Informed Inspection Notebook which incorporates the updated Significance Determination Process (SDP) Phase 2 Worksheets that inspectors will be using to characterize and risk-inform inspection findings. This document is one of the key implementation tools of the reactor safety SDP in the reactor oversight process and is also publically available through the Nuclear Regulatory Commission (NRC) external website at <http://www.nrc.gov/NRC/IM/hopetree.pdf>.

The 1999 Pilot Plant review effort clearly indicated that significant site-specific design and risk information was not captured in the Phase 2 worksheets forwarded to you by our letter dated December 7, 1999. Subsequently, a site visit was conducted by the NRC to verify and update plant equipment configuration data and to collect site-specific risk information from your staff. The enclosed document reflects the results of this visit.

The enclosed Phase 2 Worksheets have incorporated much of the information we obtained during our site visits. The staff encourages further licensee comments where it is identified that the Worksheets give inaccurately low significance determinations. Any comments should be provided to the Document Control Desk, with a copy to the Chief, Probabilistic Safety Assessment Branch, Nuclear Reactor Regulation. We will continue to assess SDP accuracy and update the document based on continuing experience.

While the enclosed Phase 2 Worksheets have been verified by our staff to include the site specific data we will continue to assess its accuracy throughout implementation and update the document based on comments by our inspectors and your staff.

H. Keiser

- 2 -

If you have any questions, please contact me at (301) 415-1420.

Sincerely,

/RA/

Richard B. Ennis, Project Manager, Section 2
Project Directorate I
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-354

Enclosure: Risk-Informed Inspection Notebook

cc w/encl: See next page

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**RISK-INFORMED INSPECTION NOTEBOOK FOR
HOPE CREEK GENERATION STATION**

BWR-4, GE, WITH MARK I CONTAINMENT

Prepared by

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NOTICE

This notebook was developed for the NRC's inspection teams to support risk-informed inspections. The "Reactor Oversight Process Improvement," SECY-99-007A, March 1999 discusses the activities involved in these inspections. The user of this notebook is assumed to be an inspector with an extensive understanding of plant-specific design features and operation. Therefore, the notebook is not a stand-alone document, and may not be suitable for use by non-specialists. It will be periodically updated with new or replacement pages incorporating additional information on this plant. All recommendations for improvement of this document should be forwarded to the Chief, Probabilistic Safety Assessment Branch, NRR, with a copy to the Chief, Inspection Program Branch, NRR.

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ABSTRACT

This notebook contains summary information to support the Significance Determination Process (SDP) in risk-informed inspections for the Hope Creek Generation Station.

The information includes the following: Categories of Initiating Events Table, Initiators and System Dependency Table, SDP Worksheets, and SDP Event Trees. This information is used by the NRC's inspectors to identify the significance of their findings, i.e., in screening risk-significant findings, consistent with Phase-2 screening in SECY-99-007A. The Categories of Initiating Event Table is used to determine the likelihood rating for the applicable initiating events. The SDP worksheets are used to assess the remaining mitigation capability rating for the applicable initiating event likelihood ratings in identifying the significance of the inspector's findings. The Initiators and System Dependency Table and the SDP Event Trees (the simplified event trees developed in preparing the SDP worksheets) provide additional information supporting the use of SDP worksheets.

The information contained herein is based on the licensee's Individual Plant Examination (IPE) submittal, the updated Probabilistic Risk Assessment (PRA), and system information obtained from the licensee during site visits as part of the review of earlier versions of this notebook. Approaches used to maintain consistency within the SDP, specifically within similar plant types, resulted in sacrificing some plant-specific modeling approaches and details. Such generic considerations, along with changes made in response to plant-specific comments, are summarized.

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1. INFORMATION SUPPORTING SIGNIFICANCE DETERMINATION PROCESS (SDP)

SECY-99-007A (NRC, March 1999) describes the process for making a Phase-2 evaluation of the inspection findings. In Phase 2, the first step is to identify the pertinent core damage scenarios that require further evaluation consistent with the specifics of the inspection findings. To aid in this process, this notebook provides the following information:

1. Estimated Likelihood Rating for Initiating Events Categories
2. Initiator and System Dependency Table
3. Significance Determination Process (SDP) Worksheets
4. SDP Event Trees.

Table 1, Categories of Initiating Events, is used to obtain the estimated likelihood rating for applicable initiating events for the plant for different exposures times for degraded conditions. This Table follows the format of the Table 1 contained in SECY-99-007A. Initiating events are grouped in frequency bins covering one order of magnitude. The table includes the initiating events that should be considered for the plant and for which SDP worksheets are provided. Categorization of the following initiating events is based on industry-average frequency: transients (Reactor Trip) (TRANS); transients without power conversion system (TPCS); large, medium, and small loss of coolant accidents (LLOCA, MLOCA, and SLOCA); inadvertent or stuck open relief valve (IORV or SORV); anticipated transients without scram (ATWS); interfacing systems LOCA (ISLOCA) and LOCA outside containment (LOC). The frequency of the remaining initiating events vary significantly from plant to plant, and accordingly, they are categorized using the plant-specific frequency obtained from the licensee. These initiating events include loss of offsite power (LOOP) and special initiators caused by loss of support systems.

The Initiator and System Dependency Table shows the major dependencies between frontline and support systems, and identifies their involvement in different types of initiators. This table identifies the most risk-significant systems; it is not an exhaustive nor comprehensive compilation of the dependency matrix, as shown in Probabilistic Risk Assessments (PRAs). This table is used to identify the SDP worksheets to be evaluated, corresponding to inspection findings on systems and components.

To evaluate the impact of an inspection finding on the core-damage scenarios, we developed the SDP worksheets. They contain two parts. The first part identifies the functions, the systems, and the combinations thereof that can perform mitigating functions, the number of trains in each system, and the number of trains required (success criteria) for each the initiator. It also characterizes the mitigation capability in terms of the available hardware (e.g., 1 train, 1 multi-train system) and the operator action involved. The second part of the SDP worksheet contains the

core-damage accident sequences associated with each initiator; these sequences are based on SDP event trees. In the parentheses next to each of the sequences the corresponding event tree branch number(s) representing the sequence is included. Multiple branch numbers indicate that the different accident sequences identified by the event tree are merged into one through the Boolean reduction.

SDP worksheets are developed for each initiating event, including "Special Initiators," which are typically caused by complete or partial loss of support systems. A special initiator typically leads to a reactor scram and degrades some front-line or support systems (e.g., Loss of Service water in BWRs). The SDP worksheets for initiating events that directly lead to core damage are different. Of this type of initiating events, only the interfacing system LOCA (ISLOCA) and LOCA outside containment (LOC) are included. This worksheet identifies the major consequential leak paths and the number of barriers that may fail to cause the initiator to occur.

For the special initiators, we considered those plant-specific initiators whose contribution to the plant's core damage frequency (CDF) is non-negligible and/or have the potential to be a significant contributor to CDF given an inspection finding on system trains and components. We defined a set of criteria for their inclusion to maintain some consistency across the plants. These conditions are as follows:

1. The special initiator should degrade at least one of the mitigating safety functions changing its mitigation capability in the worksheet. For example, a safety function with two redundant trains, classified as a multi-train system, degrades to an one-train system, to be classified as 1 Train, due to the loss of one of the trains as a result of the special initiator.
2. The special initiators, which degrade the mitigation capability of the accident sequences associated with the initiator from comparable transient sequences by two and higher orders of magnitude, must be considered.

Following the above considerations, the classes of initiators that we consider in this notebook are:

1. Transients with power conversion system (PCS) available, called Transients (Reactor trip) (TRANS),
2. Transients without PCS available, called Transients w/o PCS (TPCS),
3. Small Loss of Coolant Accident (SLOCA),
4. Inadvertent or Stuck-open Power Operated Relief Valve (IORV or SORV),
5. Medium LOCA (MLOCA),
6. Large LOCA (LLOCA),
7. Loss of Offsite Power (LOOP)
8. Anticipated Transients Without Scram (ATWS).

Section 1.3 lists the plant-specific special initiators addressed in this notebook. Examples of special initiators are as follows:

1. LOOP with failure of 1 Emergency AC (LEAC) bus or associated EDG (LEAC),
2. LOOP with stuck open SORV (LORV),
3. Loss of 1 DC Bus (LDC),
4. Loss of component cooling water (LCCW),
5. Loss of instrument air (LOIA),
6. Loss of service water (LSW).

The worksheet for the LOOP may include LOOP with emergency AC power (EAC) available and LOOP without EAC, i.e., Station Blackout (SBO). LOOP with partial availability of EAC, i.e., LOOP with loss of a bus of EAC, is covered in a separate worksheet to avoid making the LOOP worksheet too large. LOOP with stuck open SORV is also covered in a separate worksheet, when applicable. In some plants, LOOP with failure of 1 EAC bus and LOOP with stuck-open SORV are large contributors to the plant's core damage frequency (CDF).

Following the SDP worksheets, the SDP event trees corresponding to each of the worksheets are presented. The SDP event trees are simplified event trees developed to define the accident sequences identified in the SDP worksheets. For special initiators whose event tree closely corresponds to another event tree (typically, the Transient(Reactor trip) or Transients w/o PCS event tree) with one or more functions eliminated or degraded, a separate event tree may not be drawn.

We considered the following items in establishing the SDP event trees and the core-damage sequences in the SDP worksheets; Section 2.1 gives additional guidelines and assumptions.

1. Event trees and sequences were developed such that the worksheet contains all the major accident sequences identified by the plant-specific IPEs or PRAs. The special initiators modeled for a plant is based on a review of the special initiators included in the plant IPE/PRA and the information provided by the licensee.
2. The event trees and sequences for each plant took into account the IPE/PRA models and event trees for all similar plants. Any major deviations in one plant from similar plants typically are noted at the end of the worksheet.
3. The event trees and the sequences were designed to capture core-damage scenarios, without including containment-failure probabilities and consequences. Therefore, branches of event trees that are only for the purpose of a Level II PRA analysis are not considered. The resulting sequences are merged using Boolean logic.
4. The simplified event-trees focus on classes of initiators, as defined above. In so doing, many separate event trees in the IPEs often are represented by a single tree. For example, some IPEs define four or more classes of LOCAs rather than the three classes considered here. The sizes of LOCAs for which high-pressure injection is not required are some times divided into two classes; the only difference between them being the need for reactor scram in the

smaller break size. Some consolidation of transient event tree may also be done besides defining the special initiators following the criteria defined above.

5. Major actions by the operator during accident scenarios are credited using four categories of Human Error Probabilities (HEPs). They are termed operator action=1 (representing an error probability of $5E-2$ to 0.5), operator action=2 (error probability of $5E-3$ to $5E-2$), operator action=3 (error probability of $5E-4$ to $5E-3$), and operator action=4 (error probability of $5E-5$ to $5E-4$). An human action is assigned to a category bin, based on a generic grouping of similar actions among a class of plants. This approach resulted in designation of some actions to a higher bin, even though the IPE/PRA HEP value may have been indicative of a lower category. In such cases, it is noted at the end of the worksheet. On the other hand, if the IPE/PRA HEP value suggests a higher category than that generically assumed, the HEP is assigned to a bin consistent with the IPE/PRA value in recognition of potential plant-specific design; a note is also given in these situations. Operator's actions belonging to category 4, i.e., operator action=4, may only be noted at the bottom of worksheet because, in those cases, equipment failures may have the dominating influence in determining the significance of the findings.

The four sections that follow include the Categories of Initiating Events Table, Initiators and System Dependency Table, SDP Worksheets, and the SDP Event Trees for the Hope Creek Generation Station.

1.1 INITIATING EVENT LIKELIHOOD RATINGS

Table 1 presents the applicable initiating events for this plant and their estimated likelihood ratings corresponding to the exposure time for degraded conditions. The initiating events are grouped into rows based on their frequency. As mentioned earlier, loss of offsite power and special initiators are assigned to rows using the plant-specific frequency obtained from individual licensees. For other initiating events, industry-average values are used, as per SECY-99-007A.

Table 1 Categories of Initiating Events for Hope Creek Generation Station

| Row | Approximate Frequency | Example Event Type | Estimated Likelihood Rating | | |
|-----|--|---|---|-----------|----------|
| | | | A | B | C |
| I | > 1 per 1-10 yr | Reactor Trip (TRANS), Loss of Power Conversion System (Loss of condenser, Closure of MSIVs, Loss of feedwater) (TPCS) | A | B | C |
| II | 1 per 10-10 ² yr | Loss of offsite power (LOOP), Inadvertent or stuck open SRVs (IORV), Loss of Instrument Air(LOIA) | B | C | D |
| III | 1 per 10 ² - 10 ³ yr | | C | D | E |
| IV | 1 per 10 ³ - 10 ⁴ yr | Small LOCA (RCS rupture) (SLOCA), Medium LOCA (RCS rupture) (MLOCA), Loss of Service Water including Safety Auxiliaries Cooling System (LOSW) | D | E | F |
| V | 1 per 10 ⁴ - 10 ⁵ yr | Large LOCA (RCS rupture) (LLOCA), ATWS | E | F | G |
| VI | less than 1 per 10 ⁵ yr | ISLOCA, Vessel rupture | F | G | H |
| | | | > 30 days | 3-30 days | < 3 days |
| | | | Exposure Time for Degraded Condition | | |

Note:

1. The SDP worksheets for ATWS core damage sequences assume that the ATWS is not recoverable by manual actuation of the reactor trip function or by ARI (for BWRs). Thus, the ATWS frequency to be used by these worksheets must represent the ATWS condition that can only be mitigated by the systems shown in the worksheet (e.g., boration).

1.2 INITIATORS AND SYSTEM DEPENDENCY

Table 2 provides the list of the systems included in the SDP worksheets, the major components in the systems, and the support system dependencies. The system involvement in different initiating events are noted in the last column.

Table 2 Initiators and Dependency Table for Hope Creek

| Affected System | Major Components | Support Systems | Initiating Event Scenarios |
|-----------------------------|---|--|---|
| SRVs | 14 SRVs including 5 ADS valves | 125 V-DC (Bus B and D), Instrument Gas System (partial dependence) ⁽¹⁾ , ESF | All but LLOCA |
| PCS | 3 MD condensate pumps, 3 TD feed pumps, 2 condensate transfer pumps | 7.2 kV (offsite power), 120 V-AC (Bus A), 250 V-DC (for oil pumps), 480 V-AC (non class 1E), Instrument Air, Instrument Gas System | TRAN, SLOCA, IORV |
| RHR/LPCI | 4 MDPs MOVs HX | 4160 V-AC, 480 V-AC, 125 V-DC, SAC ⁽²⁾ (Safety Auxiliary Cooling), ESF | TRAN, TPCS, LOIA, LOOP, ATWS, SLOCA, IORV, MLOCA, LLOCA |
| EDGs | Engine Generator | 125 V-DC, 120 V-AC, SAC, Ventilation/Cooling | LOOP |
| SAC | 4 50% MDPs MOVs HX | SW, 480 V-AC, 120 V-AC, 125 V-DC, 4160 V-AC, ESF | All |
| SW | 4 MDPs MOVs | 4160 V-AC, 480 V-AC, 125 V-DC | LOSW |
| HPCI | TDP | 480 V-AC (Bus A for room cooling), 125 V-DC (Bus A), 250 V-DC (Bus A), SAC ⁽²⁾ , ESF | All but LLOCA |
| CS | 4 MDPs MOVs | 4160 V-AC, 480 V-AC (Bus A and B), 125 V-DC (Bus A and B), SAC ⁽²⁾ , ESF | All |
| Control Rod Hydraulic (CRD) | 2 MDPs Valves | 480 V-AC (Bus C and D) ⁽³⁾ , Reactor Auxiliary Cooling, Instrument Air | TRAN, TPCS, LOOP, ATWS |

Table 2 (Continued)

| Affected System | Major Components | Support Systems | Initiating Event Scenarios |
|--------------------------------|---|--|--|
| RCIC | TDP | 480 V-AC (Bus B for room cooling), 125 V-DC (Bus B), 250 V-DC (Bus B), SAC ⁽²⁾ , ESF | TRAN, TPCS, LOIA, LOSW, LOOP, ATWS, SLOCA, IORV, |
| Air (IA and IGS) | Air Comp. | Offsite power (7.2 kV), 480 V-AC, 125 V-DC, Reactor Auxiliary Cooling (RAC), and SAC | LOIA |
| SLC | MDP MOV | 480 V-AC | ATWS |
| Containment Venting (CV) | 6" and 12" pipe, AOVs | 120V AC Bus A and D (Partial Dependence), IA (partial dependence) | All |
| AC Power | 7.2 KV Bus A & B, 4.16 KV Buses, 480 V Channels, & 120 V channels | 480 V-AC (4.16 KV Buses), 120 V-AC (480 V-AC channels, partial dependency ⁽¹⁾), 125 V-DC (partial dependency ⁽¹⁾), Ventilation/Cooling | All |
| DC Power | 250 V Bus A & B, 125 V Chnl A, B, C, & D | 480 V-AC (partial dependence) ⁽¹⁾ , | All |
| Emergency Safety Feature (ESF) | 4 channels for HPCI, RCIC, RHR and CSS initiations; 2 channels for SLC initiation | 125V DC | All |

Table 2 (Continued)

| Affected System | Major Components | Support Systems | Initiating Event Scenarios |
|-----------------------------------|---|--|---------------------------------|
| Reactor Auxiliaries Cooling (RAC) | 3 50% pumps, 2 50% HXs, 1 HX Bypass FCV, & 1 expansion tank | 480 V-AC, IA, SW (partial dependence) ⁽¹⁾ | LOIA |
| Ventilation & Cooling | Dampers & Fans | 480 V-AC, SAC (partial dependence) ⁽¹⁾ | All |
| Firewater Pump | 1 MD and 1 DD | Non-Class 1E 480 VAC (MD Fire pump) | All except MLOCA, LLOCA, & ATWS |

Notes:

1. Partial dependence signifies that if the system fails the frontline or support system in question does not necessarily fail, but a combination of partial failures could result in the system failure.
2. SAC provides pump room cooling for HPCI, RCIC, RHR, and CS systems.
3. These loads are shed on a LOCA signal.
4. The internal event CDF is estimated at 4.58E-5/yr.

1.3 SDP WORKSHEETS

This section presents the SDP worksheets to be used in the Phase 2 evaluation of the inspection findings for the. The SDP worksheets are presented for the following initiating event categories:

1. Transients (Reactor Trip) (TRANS)
2. Transients without PCS (TPCS)
3. Transients with Loss of Service Water (LOSW)
4. Loss of Instrument Air (LOIA)
5. Small LOCA (SLOCA)
6. Inadvertent/Stuck Open Relief Valve (IORV/SORV)
7. Medium LOCA (MLOCA)
8. Large LOCA (LLOCA)
9. Loss of Off-site Power (LOOP)
10. Anticipated Transients Without Scram (ATWS)
11. Interfacing System LOCA (ISLOCA)

Table 3.1 SDP Worksheet for Hope Creek — Transients (Reactor Trip) (TRANS)

| Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H | | | |
|---|---------------------------------|---|-----------------------|
| Safety Functions Needed: Power Conversion System (PCS) High Pressure Injection (HPI) Depressurization (DEP) Low Pressure Injection (LPI) Containment Heat Removal (CHR) Containment Venting (CV) Late Inventory, Makeup (LI) | | Full Creditable Mitigation Capability for Each Safety Function: 1/3 condenser, 1/3 condensate pumps, 1/3 main feed pumps (operator action = 3) HPCI (1 ASD train) or RCIC (1 ASD train) 2/14 SRVs manually opened (operator action = 2) ⁽¹⁾ 1/4 RHR trains in LPCI mode ⁽²⁾ (1 multi-train system) or 1/2 LPCS train with 2 pumps /train (1 multi-train system) 1/2 (A or B) RHR pumps in SPC or CSC mode (1 multi-train system) ⁽²⁾ Containment venting 12" HPCVs or 6" ILRT or 6" drywell supply (operator action = 2) 2/2 CRD pumps or 2/2 condensate transfer pump or 1 of motor- or diesel-driven firewater pump (operator action = 2) ⁽³⁾ | |
| Circle Affected Functions: | Recovery of Failed Train | Remaining Mitigation Capability Rating for Each Affected Sequence | Sequence Color |
| 1 TRAN - PCS - CHR - CV (5, 9) | | | |
| 2 TRAN- PCS - CHR - LI (4, 8) | | | |
| 3 TRAN - PCS - HPI - DEP (11) | | | |
| 4 TRAN - PCS - HPI - LPI (10) | | | |

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. For depressurization (DEP) using SRVs, Hope Creek PRA assigns a failure probability $\sim 5E-3$. An operator action credit of 2 is assigned based on survey of plants of similar designs.
2. On a LPCI signal, all four RHR pumps start and the system automatically aligns to deliver suppression pool water from torus to the reactor vessel. RHR trains C and D are dedicated to the LPCI configuration and cannot be aligned to support any other operational mode. RHR trains A and B will also automatically align to support LPCI operation where the discharge is directed through the RHR HX bypass valves and then into the vessel via the injection valves.
3. In CHR, use of RHR pumps in SPC or CSC is considered 1 multi-train system, since the operator action involved has a low error probability.
4. In LI, credit is given for use of CRD pumps, condensate transfer pump and firewater pumps; Hope Creek emergency procedure specifically describes the use of these systems. An operator action credit of 2 is assigned.

Table 3.2 SDP Worksheet for Hope Creek — Transients (w/o PCS) (TPCS)

| | | | |
|---|---------------------------------|---|-----------------------|
| Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H | | | |
| Safety Functions Needed: High Pressure Injection (HPI) Depressurization (DEP) Low Pressure Injection (LPI) Containment Heat Removal (CHR) Containment Venting (CV) Late Inventory, Makeup (LI) | | Full Creditable Mitigation Capability for Each Safety Function: HPCI (1 ASD train) or RCIC (1 ASD train) 2/14 SRVs manually opened (operator action = 2) ⁽¹⁾ 1/4 RHR train in LPCI mode (1 multi-train system) or 1/2 LPCS train with 2 pumps/ train (1 multi-train system) 1/2 (A or B) RHR pumps in SPC or CSC mode (1 multi-train system) ⁽²⁾ Containment venting 12" HPCVs or 6" ILRT or 6" drywell supply (operator action = 2) 2/2 CRD pumps or 2/2 condensate transfer pump or 1 of motor- or diesel-driven firewater pump (operator action = 2) ⁽³⁾ | |
| Circle Affected Functions: | Recovery of Failed Train | Remaining Mitigation Capability Rating for Each Affected Sequence | Sequence Color |
| 1 TPCS - CHR - CV (4, 8) | | | |
| 2 TPCS - CHR - LI (3, 7) | | | |
| 3 TPCS - HPI - DEP (10) | | | |
| 4 TPCS - HPI - LPI (9) | | | |

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. For depressurization (DEP) using SRVs, Hope Creek PRA assigns a failure probability $\sim 5E-3$. An operator action credit of 2 is assigned based on survey of plants of similar designs.
2. In CHR, use of RHR pumps in SPC or CSC is considered 1 multi-train system, since the operator action involved has a low error probability.
3. In LI, credit is given for use of CRD pumps, condensate transfer pump and firewater pumps; Hope Creek emergency procedure specifically describes the use of these systems. An operator action credit of 2 is assigned.

Table 3.3 SDP Worksheet for Hope Creek — Loss of Service Water (LOSW)^(1,2)

| | | | |
|---|---------------------------------|--|-----------------------|
| Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H | | | |
| Safety Functions Needed: High Pressure Injection (HPI) Depressurization (DEP) Low Pressure Injection (LPI) Containment Venting (CV) Late Inventory, Makeup (LI) | | Full Creditable Mitigation Capability for Each Safety Function: HPCI (1 ASD train) or RCIC (1 ASD train) 2/14 SRVs manually opened (operator action = 2) 1/2 LPCS train with 2 pumps/train (1 multi-train system) Containment venting 12" HPCVs or 6" ILRT or 6" drywell supply (operator action = 2) ⁽³⁾ 2/2 condensate transfer pump or 1 of motor- or diesel-driven firewater pump (operator action = 2) | |
| Circle Affected Functions: | Recovery of Failed Train | Remaining Mitigation Capability Rating for Each Affected Sequence | Sequence Color |
| 1 LOSW - LI (2, 5) | | | |
| 2 LOSW - CV (3, 6) | | | |
| 3 LOSW - HPI - LPI (7) | | | |
| 4 LOSW - HPI - DEP (8) | | | |

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. Loss of Service Water (LOSW) includes loss of station service water (SSW) and loss of safety auxiliaries cooling system (SACS). The IE frequency is $2.1E-4$ /year.
2. Upon loss of SSW or SACS, loss of heat removal to various pumps, heat exchangers, and chiller equipment as well as loss of turbine auxiliaries cooling system (TACS) and other mitigating equipment failures will occur within a fairly short time. These effects will cause heatup of equipment associated with the power conversion system, the inability to cool RHR pumps, RHR heat exchangers, instrument gas compressors, and ECCS pump rooms. HPCI, RCIC or Core Spray system room cooling is affected by the loss of SACS, but it is assumed they will operate as expected. Inspector may assess if these equipment can operate for the long period without room cooling.
3. Failure of containment venting is assumed to cause core damage. No credit is given for continued operation of HPCI or RCIC.

Table 3.4 SDP Worksheet for Hope Creek — Loss of Instrument Air (LOIA)⁽¹⁾

| Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H | | | |
|---|---------------------------------|--|-----------------------|
| Safety Functions Needed: High Pressure Injection (HPI) Depressurization (DEP) Low Pressure Injection (LPI) Containment Heat Removal (CHR) Containment Venting (CV) Late Inventory, Makeup (LI) | | Full Creditable Mitigation Capability for Each Safety Function: HPCI (1 ASD train) or RCIC (1 ASD train) 2/14 SRVs manually opened (operator action = 2) 1/4 RHR train in LPCI mode (1 multi-train system) or 1/ 2 LPCS train with 2 pumps/train (1 multi-train system) 1/2 (A or B) RHR pumps in SPC or CSC mode (1 multi-train system) Containment venting 12" HPCVs or 6" ILRT or 6" drywell supply (operator action = 2) ⁽²⁾ 2/2 condensate transfer pump or 1 of motor- or diesel-driven firewater pump (operator action = 2) | |
| Circle Affected Functions: | Recovery of Failed Train | Remaining Mitigation Capability Rating for Each Affected Sequence | Sequence Color |
| 1 LOIA - CHR - LI (3, 7) | | | |
| 2 LOIA - CHR - CV (4, 8) | | | |
| 3 LOIA - HPI - LPI (9) | | | |
| 4 LOIA - HPI - DEP (10) | | | |

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. Loss of instrument air (LOIA) includes also loss of Service air. LOIA at Hope Creek will cause outboard MSIV closure, control rod drift, and affect feedwater/condensate, CRD, and limit containment venting activation choices. IE frequency for LOIA is 1.0E-2. No separate event tree is provided; please refer to the TPCS tree.
2. Containment venting is done via nitrogen bottles and manual action. Failure of containment venting is assumed to cause core damage. No credit is given for continued operation of HPCI or RCIC.

Table 3.5 SDP Worksheet for Hope Creek — Small LOCA (SLOCA)

| | | | |
|--|---------------------------------|--|-----------------------|
| Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H | | | |
| Safety Functions Needed: Power Conversion System (PCS) High Pressure Injection (HPI) Depressurization (DEP) Low Pressure Injection (LPI) Containment Heat Removal (CHR) Containment Venting (CV) Late Inventory, Makeup (LI) | | Full Creditable Mitigation Capability for Each Safety Function: 1/3 condenser, 1/3 condensate pumps, 1/3 main feed pumps (operator action = 2) ⁽¹⁾ HPCI (1 ASD train) or RCIC (1 ASD train) 2/14 SRVs manually opened (operator action = 2) ⁽²⁾ 1/4 RHR trains in LPCI mode (1 multi-train system) or 1/2 LPCS trains with 2 pumps/train (1 multi-train system) 1/2 (A or B) RHR pumps in SPC or CSC mode (1 multi-train system) ⁽³⁾ Containment venting 12" HPCVs or 6" ILRT or 6" drywell supply (operator action = 2) 2/2 Condensate transfer pump or 1 of motor- or diesel-driven firewater pump (operator action = 2) ⁽⁴⁾ | |
| Circle Affected Functions: 1 SLOCA - PCS - CHR - CV (5, 10) | Recovery of Failed Train | Remaining Mitigation Capability Rating for Each Affected Sequence | Sequence Color |
| 2 SLOCA -PCS -CHR - LI (4, 9) | | | |
| 3 SLOCA - PCS -LPI ⁽⁵⁾ (6,11) | | | |
| 4 SLOCA - PCS - HPI - DEP (12) | | | |

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. Failure to prevent a trip of feedpumps during a SLOCA is assigned a probability of $5E-03$. A operator action credit of 2 is assigned.
2. For depressurization (DEP) using SRVs, Hope Creek PRA assigns a failure probability $\sim 5E-3$. An operator action credit of 2 is assigned based on survey of plants of similar designs.
3. In CHR, use of RHR pumps in SPC or CSC is considered 1 multi-train system, since the operator action involved has a low error probability.
4. In LI, credit is given for use of condensate transfer pump and firewater pumps; Hope Creek emergency procedure specifically describes the use of these systems. An operator action credit of 2 is assigned.
5. In a SLOCA scenario, following PCS failure, but successful HPI, the ability to spin the HPI turbines will be lost at some time when the reactor is depressurized and LPI will be needed.

Table 3.6 SDP Worksheet for Hope Creek — Inadvertent/Stuck Open Relief Valve (IORV/SORV)⁽¹⁾

| Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H | | | |
|---|---------------------------------|---|-----------------------|
| Safety Functions Needed: Power Conversion System (PCS) High Pressure Injection (HPI) Depressurization (DEP) Low Pressure Injection (LPI) Containment Heat Removal (CHR) Containment Venting (CV) Late Inventory, Makeup (LI) | | Full Creditable Mitigation Capability for Each Safety Function: 1/3 Feedwater pumps with 1/3 Condensate pumps (no credit) ⁽²⁾ HPCI (1ASD train) or RCIC (1 ASD train) Operator depressurizes through 1 of 5 ADS or 9 SRVs (operator action = 2) 1/4 RHR trains in LPCI mode (1 multi-train system) or 1/2 LPCS trains with 2 pumps/train (1 multi-train system) 1/2 (A or B) RHR pumps in SPC or CSC mode (1 multi-train system) Containment venting 12" HPCVs or 6" ILRT or 6" drywell supply (operator action = 2) 2/2 CRD pumps or 2/2 condensate transfer pump or 1 of motor- or diesel-driven fire pump (operator action = 2) | |
| Circle Affected Functions: | Recovery of Failed Train | Remaining Mitigation Capability Rating for Each Affected Sequence | Sequence Color |
| 1 IORV - CHR - CV (5, 10,14) | | | |
| 2 IORV -- CHR - LI (4, 9, 13) | | | |
| 3 IORV - LPI - LI (7) | | | |
| 4 IORV - HPI - DEP (16) | | | |

| | | | |
|---|--|--|--|
| 5 IORV - HPI - LPI (15) | | | |
| <p>Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:</p> <p>If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.</p> | | | |

Note:

1. Reactor scram is initiated by the operator if the open SRV cannot be closed within 2 minutes.
2. SRVs may fail to reclose when demanded in transients such as MSIV closure or turbine trip without bypass. In such transients, the PCS function could not be credited. Considering such scenarios, this SDP worksheet conservatively does not credit PCS.

Table 3.7 SDP Worksheet for Hope Creek — Medium LOCA (MLOCA)

| | | | |
|--|---------------------------------|---|-----------------------|
| Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H | | | |
| Safety Functions Needed: Early Inventory (EI) Early Containment Control (EC) Depressurization (DEP) Low Pressure Injection (LPI) Containment Heat Removal (CHR) Containment Venting (CV) Late Inventory, Makeup (LI) | | Full Creditable Mitigation Capability for Each Safety Function: HPCI (1 ASD train) Passive operation of SP, 7 vacuum breakers remain closed and 1/8 open, when needed (1 multi-train system) Operator depressurizes through 1 of 5 ADS or 9 SRVs (operator action = 2) 1/4 RHR trains in LPCI mode (1 multi-train system) or 1/2 LPCS trains with 2 pumps/train (1 multi-train system) 1/2 (A or B) RHR pumps in SPC or CSC mode (1 multi-train system) Containment venting 12" HPCVs or 6" ILRT or 6" drywell supply (operator action = 2) 1/3 condensate train (operator action = 2) ⁽¹⁾ | |
| Circle Affected Functions: | Recovery of Failed Train | Remaining Mitigation Capability Rating for Each Affected Sequence | Sequence Color |
| 1 MLOCA - CHR - CV (4, 9) | | | |
| 2 MLOCA - CHR - LI (3, 8) | | | |
| 3 MLOCA - EI - DEP (11) | | | |
| 4 MLOCA - LPI (5, 10) | | | |

| | | | |
|---|--|--|--|
| 5 MLOCA - EC (12) | | | |
| <p>Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:</p> <p>If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.</p> | | | |

Note:

1. In late inventory (LI) using firewater and condensate transfer pumps by operators is not considered due to inadequate capacity or time.

Table 3.8 SDP Worksheet for Hope Creek — Large LOCA (LLOCA)

| | | | |
|---|--|--|-----------------------|
| Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H | | | |
| Safety Functions Needed: Early Inventory (EI) Early Containment Control (EC) Containment Heat Removal (CHR) Containment Venting (CV) Late Inventory, Makeup (LI) | Full Creditable Mitigation Capability for Each Safety Function: 1/4 RHR train in LPCI mode (1 multi-train system) or 1/2 LPCS train with 2 pumps per train (1 multi-train system) Passive operation of SP, 7/8 vacuum breakers remain closed and 1/8 open, when needed (1 multi-train system) 1/2 (A or B) RHR pumps in SPC or CSC mode (1 multi-train system) Containment venting 12" HPCVs or 6" ILRT or 6" drywell supply (operator action = 2) 1/3 condensate trains (operator action = 2) | | |
| Circle Affected Functions: | <u>Recovery of Failed Train</u> | <u>Remaining Mitigation Capability Rating for Each Affected Sequence</u> | <u>Sequence Color</u> |
| 1 LLOCA - EC (6) | | | |
| 2 LLOCA - EI (5) | | | |
| 3 LLOCA - CHR - LI (3) | | | |
| 4 LLOCA - CHR - CV (4) | | | |

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Note:

1. In late inventory (LI) using firewater and condensate transfer pumps by operators is not considered due to inadequate capacity or time.

Table 3.9 SDP Worksheet for Hope Creek — Loss of Offsite Power (LOOP)

| | | | |
|--|---------------------------------|--|-----------------------|
| Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H | | | |
| Safety Functions Needed: Emergency Power (EAC) Recovery of LOOP in 45 mins (RLOOP45M) Recovery of LOOP in 5 hours (RLOOP5HR) High Pressure Injection (HPI) Depressurization (DEP) Low Pressure Injection (LPI) Containment Heat Removal (CHR) Containment Venting (CV) Late Inventory, Makeup (LI) | | Full Creditable Mitigation Capability for Each Safety Function: 2/4 EDGs (1 multi-train system), or tie to Salem gas turbine if feasible (operator action = 1) Operator action = 1 Operator action = 2 HPCI (1 ASD train) or RCIC (1 ASD train) 2/14 SRVs manually opened (operator action = 2) 1/4 RHR train in LPCI mode (1 multi-train system) or 1/2 LPCS train with 2 pumps/train (1 multi-train system) 1/2 (A or B) RHR pumps in SPC or CSC mode (1 multi-train system) Containment venting 12" HPCVs or 6" ILRT or 6" drywell supply (operator action = 2) DEP using 2/14 SRVs with 2/2 CRD pumps or 1 of motor- or diesel-driven firewater pump (operator action = 2) | |
| Circle Affected Functions: | Recovery of Failed Train | Remaining Mitigation Capability Rating for Each Affected Sequence | Sequence Color |
| 1 LOOP - EAC - HPI - RLOOP45 M (25) | | | |
| 2 LOOP - EAC - RLOOP5 HR (26) | | | |
| 3 LOOP - HPI - DEP (10, 20) | | | |

| | | | |
|---|--|--|--|
| 4 LOOP - HPI - LPI (9, 19) | | | |
| 5 LOOP - CHR- CV (4, 8, 14, 18) | | | |
| 6 LOOP - CHR - LI (3, 7, 13, 17) | | | |
| Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event: | | | |
| If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use. | | | |

Notes:

1. Recovery of LOOP in 45 min is considered an operator action with a credit of 1. HCPRA assigns a failure probability of ~5.5E-1.
2. Battery depletion is expected at 4 hours. Recovery of LOOP in 5 hrs is considered an operator action with a credit of 2. HCPRA assigns a failure probability of ~5E-2.
3. In sequences 3 and 4, either EAC or recovery of LOOP in 45 mins is successful.
4. In sequences 5 and 6, either EAC or recovery of LOOP in 5 hrs is successful.

Table 3.10 SDP Worksheet for Hope Creek — Anticipated Transients Without Scram (ATWS)

| Estimated Frequency (Table 1 Row) _____ Exposure Time _____ Table 1 Result (circle): A B C D E F G H | | | |
|---|---------------------------------|--|-----------------------|
| Safety Functions Needed: Overpressure Protection (OVERP) Reactivity Control (SLC) Recirculation Pump Trip (RPT) High Pressure Injection (HPI) Depressurization (DEP) Inhibit ADS and HPCI Path (INH) Low Press Injection (LPI) Containment Heat Removal (CHR) Containment Venting (CV) Late Inventory, Makeup (LI) | | Full Creditable Mitigation Capability for Each Safety Function: 8/14 SRVs (1 multi-train system) Maintain level and initiate SLC (operator action = 2) Manual or automatic trip of recirculation pumps (1 multi-train system) HPCI (1 ASD train) or RCIC (1 ASD train) 2/14 SRVs manually opened (operator action = 1) Operator inhibits ADS and core spray HPCI path (operator action = 1) 1/4 RHR train in LPCI mode (1 multi-train system) or 1/2 LPCS train with 2 pumps/train (1 multi-train system) 1/2 (A or B) RHR pumps in SPC or CSC mode (1 multi-train system) or containment venting (operator action = 2) Containment venting 12" HPCVs or 6" ILRT or 6" drywell supply (operator action = 2) 1/3 condensate pump or 2/2 CRD pumps (operator action = 2) | |
| Circle Affected Functions: 1 ATWS - OVERP (14) | Recovery of Failed Train | Remaining Mitigation Capability Rating for Each Affected Sequence | Sequence Color |
| 2 ATWS - RPT (13) | | | |
| 3 ATWS - INH (12) | | | |

| | | | |
|--|--|--|--|
| 4 ATWS - SLC (11) | | | |
| 5 ATWS - HPI - DEP (10) | | | |
| 6 ATWS - HPI - LPI (9) | | | |
| 7 ATWS - CHR - CV (4,8) | | | |
| 8 ATWS - CHR - LI (3,7) | | | |
| Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event: | | | |
| <p>If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.</p> | | | |

Notes:

1. Reactivity control using SLC includes level control and initiation of SLC; in this plant, it is considered an operator action with a credit of 2 since the plant has auto SLC initiation.
2. Operator inhibiting ADS and HPCI path is considered an operator action with a credit of 1; HCPRA assigns a failure probability of 7.5E-2.
3. Operator failure to depressurize the RPV during ATWS is assigned a credit of 1; HCPRA assigns a failure probability of 5.6E-2.

Table 3.11 SDP Worksheet for — Interfacing System LOCA (ISLOCA)

| | | | | | | | |
|---|--|---|--|--|--|------------------------------|--|
| Estimated Frequency (Table 1 Row) _____ | | Exposure Time _____ | | Table 1 Result (circle): A B C D E F G H | | | |
| Initiation Pathways: | | Mitigation Capability: <u>Ensure Component Operability for Each Pathway</u> | | | | | |
| RHR Injection Lines | | Injections Lines for pumps AP202/BP202/CP202/DP202: 1 check valve and 1 closed MOV for each | | | | | |
| RHR Shutdown Cooling Suction Line | | 2 Closed MOVs | | | | | |
| RHR Shutdown Cooling Return Line | | Return Lines for Loop A and B: 1 closed MOV and 1 check valve | | | | | |
| RHR Vessel Head Spray Line | | 2 Closed MOVs and 1 check valve | | | | | |
| Core Spray Discharge Line | | 2 lines : 1 closed MOV, 1 open MOV and 1 check valve | | | | | |
| <u>Circle Affected Component in Pathways</u> | <u>Recovery of Failed Train</u> | <u>Remaining Mitigation Capability Rating for Each Affected Pathway</u> | | | | <u>Sequence Color</u> | |
| | | | | | | | |

Identify any operator recovery actions that are credited to directly restore the degraded equipment or initiating event:

If operator actions are required to credit placing mitigation equipment in service or for recovery actions, such credit should be given only if the following criteria are met: 1) sufficient time is available to implement these actions, 2) environmental conditions allow access where needed, 3) procedures exist, 4) training is conducted on the existing procedures under conditions similar to the scenario assumed, and 5) any equipment needed to complete these actions is available and ready for use.

Notes:

1. The initiation pathways and the applicable components in the pathways are based on the licensee's inputs from the IPE, supplemented by generic insights based on NRC studies on ISLOCA.
2. The ISLOCA contribution to the Hope Creek CDF is 1.7E-09/year which is less than 0.01% of the internal event CDF.
3. This worksheet is different from the other worksheets, in that ISLOCA is typically an unmitigated initiating event in most PRAs. Therefore, the right side of the worksheet contains valves, whose failure may lead to an ISLOCA rather than mitigating systems to address an event in progress. As such, it is not intended to be referenced by the last column of Table 2, Initiators and System Dependency Table.

1.4 SDP EVENT TREES

This section provides the simplified event trees called SDP event trees used to define the accident sequences identified in the SDP worksheets in the previous section. The event tree headings are defined in the corresponding SDP worksheets.

The following event trees are included:

1. Transients (Reactor Trip) (TRANS)
2. Transients without PCS (TPCS)
3. Transients with Loss of Service Water (LOSW)
4. Small LOCA (SLOCA)
5. Inadvertent/Stuck Open Relief Valve (IORV/SORV)
6. Medium LOCA (MLOCA)
7. Large LOCA (LLOCA)
8. Loss of Off-site Power (LOOP)
9. Anticipated Transients Without Scram (ATWS)

| | TRAN | PCS | HPI | DEP | LPI | CHR | CV | LI | # | STATUS |
|--|------|-----|-----|-----|-----|-----|----|----|----|--------|
| | | | | | | | | | 1 | OK |
| | | | | | | | | | 2 | OK |
| | | | | | | | | | 3 | OK |
| | | | | | | | | | 4 | CD |
| | | | | | | | | | 5 | CD |
| | | | | | | | | | 6 | OK |
| | | | | | | | | | 7 | OK |
| | | | | | | | | | 8 | CD |
| | | | | | | | | | 9 | CD |
| | | | | | | | | | 10 | CD |
| | | | | | | | | | 11 | CD |

Plant name abbrev.: HOPE

| TPCS | HPI | DEP | LPI | CHR | CV | LI | # | STATUS |
|------|-----|-----|-----|-----|----|----|----|--------|
| | | | | | | | 1 | OK |
| | | | | | | | 2 | OK |
| | | | | | | | 3 | CD |
| | | | | | | | 4 | CD |
| | | | | | | | 5 | OK |
| | | | | | | | 6 | OK |
| | | | | | | | 7 | CD |
| | | | | | | | 8 | CD |
| | | | | | | | 9 | CD |
| | | | | | | | 10 | CD |

Plant Name Abbrev.: HOPE

| LOSW | HPI | DEP | LPI | CV | LI | # | STATUS |
|------|-----|-----|-----|----|----|---|--------|
| | | | | | | 1 | OK |
| | | | | | | 2 | CD |
| | | | | | | 3 | CD |
| | | | | | | 4 | OK |
| | | | | | | 5 | CD |
| | | | | | | 6 | CD |
| | | | | | | 7 | CD |
| | | | | | | 8 | CD |

Plant Name Abbrev.: HOPE

| SLOCA | PCS | HPI | DEP | LPI | CHR | CV | LI | # | STATUS |
|-------|-----|-----|-----|-----|-----|----|----|----|--------|
| | | | | | | | | 1 | OK |
| | | | | | | | | 2 | OK |
| | | | | | | | | 3 | OK |
| | | | | | | | | 4 | CD |
| | | | | | | | | 5 | CD |
| | | | | | | | | 6 | CD |
| | | | | | | | | 7 | OK |
| | | | | | | | | 8 | OK |
| | | | | | | | | 9 | CD |
| | | | | | | | | 10 | CD |
| | | | | | | | | 11 | CD |
| | | | | | | | | 12 | CD |

Plant Name Abbrev.: HOPE

| IORV | PCS | HPI | DEP | LPI | CHR | CV | LI | # | STATUS |
|------|-----|-----|-----|-----|-----|----|----|----|--------|
| | | | | | | | | 1 | OK |
| | | | | | | | | 2 | OK |
| | | | | | | | | 3 | OK |
| | | | | | | | | 4 | CD |
| | | | | | | | | 5 | CD |
| | | | | | | | | 6 | OK |
| | | | | | | | | 7 | CD |
| | | | | | | | | 8 | OK |
| | | | | | | | | 9 | CD |
| | | | | | | | | 10 | CD |
| | | | | | | | | 11 | OK |
| | | | | | | | | 12 | OK |
| | | | | | | | | 13 | CD |
| | | | | | | | | 14 | CD |
| | | | | | | | | 15 | CD |
| | | | | | | | | 16 | CD |

Plant Name Abbrev.: HOPE

| MLOCA | EC | EI | DEP | LPI | CHR | CV | LI | # | STATUS |
|-------|----|----|-----|-----|-----|----|----|----|--------|
| | | | | | | | | 1 | OK |
| | | | | | | | | 2 | OK |
| | | | | | | | | 3 | CD |
| | | | | | | | | 4 | CD |
| | | | | | | | | 5 | CD |
| | | | | | | | | 6 | OK |
| | | | | | | | | 7 | OK |
| | | | | | | | | 8 | CD |
| | | | | | | | | 9 | CD |
| | | | | | | | | 10 | CD |
| | | | | | | | | 11 | CD |
| | | | | | | | | 12 | CD |

Plant name abbrev.: HOPE

| | LLOCA | EC | EI | CHR | CV | LI | # | STATUS |
|--------------------------|-------|----|----|-----|----|----|---|--------|
| | | | | | | | 1 | OK |
| | | | | | | | 2 | OK |
| | | | | | | | 3 | CD |
| | | | | | | | 4 | CD |
| | | | | | | | 5 | CD |
| | | | | | | | 6 | CD |
| Plant name abbrev.: HOPE | | | | | | | | |

| LOOP | EAC | R LOOP+5 M | R LOOP+5 HR | HPI | DEP | LPI | CHR | CV | LI | # | STATUS |
|------|-----|------------|-------------|-----|-----|-----|-----|----|----|----|--------|
| | | | | | | | | | | 1 | OK |
| | | | | | | | | | | 2 | OK |
| | | | | | | | | | | 3 | CD |
| | | | | | | | | | | 4 | CD |
| | | | | | | | | | | 5 | OK |
| | | | | | | | | | | 6 | OK |
| | | | | | | | | | | 7 | CD |
| | | | | | | | | | | 8 | CD |
| | | | | | | | | | | 9 | CD |
| | | | | | | | | | | 10 | CD |
| | | | | | | | | | | 11 | OK |
| | | | | | | | | | | 12 | OK |
| | | | | | | | | | | 13 | CD |
| | | | | | | | | | | 14 | CD |
| | | | | | | | | | | 15 | OK |
| | | | | | | | | | | 16 | OK |
| | | | | | | | | | | 17 | CD |
| | | | | | | | | | | 18 | CD |
| | | | | | | | | | | 19 | CD |
| | | | | | | | | | | 20 | CD |
| | | | | | | | | | | 21 | OK |
| | | | | | | | | | | 22 | OK |
| | | | | | | | | | | 23 | CD |
| | | | | | | | | | | 24 | CD |
| | | | | | | | | | | 25 | CD |
| | | | | | | | | | | 26 | CD |

Plant name abbrev.: HOPE

| ATWS | OVERP | RPT | INH | SLC | HPI | DEP | LPI | CHR | CV | LI | # | STATUS |
|------|-------|-----|-----|-----|-----|-----|-----|-----|----|----|----|--------|
| | | | | | | | | | | | 1 | OK |
| | | | | | | | | | | | 2 | OK |
| | | | | | | | | | | | 3 | CD |
| | | | | | | | | | | | 4 | CD |
| | | | | | | | | | | | 5 | OK |
| | | | | | | | | | | | 6 | OK |
| | | | | | | | | | | | 7 | CD |
| | | | | | | | | | | | 8 | CD |
| | | | | | | | | | | | 9 | CD |
| | | | | | | | | | | | 10 | CD |
| | | | | | | | | | | | 11 | CD |
| | | | | | | | | | | | 12 | CD |
| | | | | | | | | | | | 13 | CD |
| | | | | | | | | | | | 14 | CD |

Plant Name Abbrev.: HOPE

2. RESOLUTION AND DISPOSITION OF COMMENTS

This section is composed of two subsections. Subsection 2.1 summarizes the generic assumptions that were used for developing the SDP worksheets for the BWR plants. These guidelines were based on the plant-specific comments provided by the licensee on the draft SDP worksheets and further examination of the applicability of those comments to similar plants. These assumptions which are used as guidelines for developing the SDP worksheets help the reader better understand the worksheets' scope and limitations. The generic guidelines and assumptions for BWRs are given here. Subsection 2.2 documents the plant-specific comments received on the draft version of the material included in this notebook and their resolution.

2.1 GENERIC GUIDELINES AND ASSUMPTIONS (BWRs)

Initiating Event Likelihood Rating Table

1. Assignment of plant-specific IEs into frequency rows:

Transient (Reactor trip) (TRANS), transients without PCS (TPCS), small, medium, and large LOCA (SLOCA, MLOCA, LLOCA), inadvertent or stuck-open SRVs (IORV), anticipated transients without scram (ATWS), interfacing system LOCA (ISLOCA), and LOCA outside containment (LOC) are assigned into rows based on consideration of industry-average frequency. Plant-specific frequencies can be different, but are not considered. Plant-specific frequencies for LOOP and special initiators are used to assign these initiating events.

2. Inclusion of special initiators:

The special initiators included in the worksheets are those applicable for the plant. A separate worksheet is included for each of the applicable special initiators. The applicable special initiators are primarily based on the plant-specific IPEs. In other words, the special initiator included are those modeled in the IPEs unless it is shown to be a negligible contributor. In some cases, in considering plants of similar design, a particular special initiator may be added for a plant even if it is not included in the IPE if such an initiator is included in other plants of similar design and is considered applicable for the plant. Except for the interfacing system LOCA (ISLOCA) and LOCA outside containment (LOC), if the occurrence of the special initiator results in a core damage, i.e., no mitigation capability exists for the initiating event, then a separate worksheet is not developed. For such cases, the inspection focus is on the initiating event and the risk implication of the inspection finding can be directly assessed. For ISLOCA and LOC, a separate worksheet is included noting the pathways that can lead to these events.

3. Inadvertent or stuck open relief valve as an IE in BWRs:

Many IPEs/PRA model this event as a separate initiating event. Also, the failure of the SRVs to re-close after opening can be modeled within the transient tree. In the SDP worksheet, these events are modeled in a separate worksheet (and, are not included in the transient worksheets) considering both inadvertent opening and failure to re-close. We typically consider a single valve is stuck or inadvertently open. The frequency of this initiator is generically estimated for all BWR plants. This IE may behave similar to a small or medium LOCA depending on the valve size, and the mitigation capability is addressed accordingly.

4. LOCA outside containment (LOC):

A LOCA outside of containment (LOC) can be caused by a break in a few types of lines such as Main Steam or Feedwater. LOC is treated differently among the IPEs. Separate ETs are usually not developed in the IPEs for LOCs. Thus, credit is usually not taken for mitigating actions. LOC

sequences typically have a core damage frequency in the E-8 range. As such, LOCs are included together with ISLOCAs in a separate summary type SDP worksheet. Plant specific notes are included to explain how the particular IPE has addressed LOCs.

Initiating Event and System Dependency Table

1. Inclusion of systems under the support system column:

This table shows the support systems for the support and frontline systems. Partial dependency, which usually is a backup system, is not expected to be included. If included, they should be so noted. The intent is to include only the support system and not the systems supporting the support system, i.e., those systems whose failure will result in failure of the system being supported. Sometimes, some subsystems on which inspection findings may be noted have been included as a support system, e.g., EDG fuel oil transfer pump as a support system for EDGs.

2. Coverage of system/components and functions included in the SDP worksheets:

The Initiators and System Dependency Table includes systems and components which are included in the SDP worksheets and those which can affect the performance of these systems and components. One to one matching of the ET headings/functions to that included in the Table was not considered necessary.

SDP Worksheets and Event Trees

1. Crediting of non-safety related equipment:

SDP worksheets credit or include safety-related equipment and also, non-safety related equipment as used in defining the accident sequences leading to core damage. In defining the success criteria for the functions needed, the components included are typically those covered under the Technical Specifications (TS) and the Maintenance Rule (MR). No evaluation was performed to assure that the components included in the worksheets are covered under TS or MR. However, if a component was included in the worksheet, and the licensee requested its removal, it may not have been removed if it is considered that the components is included in either TS or MR.

2. No credit for certain plant-specific mitigation capability:

The significance determination process (SDP) screens inspection findings for Phase 3 evaluations. Some conservative assumptions are made which result in not crediting some plant-specific features. Such assumptions are usually based on comparisons with plants of similar design and to maintain consistency across the SDP worksheets of similar plant designs.

3. Crediting system trains with high unavailability

Some system component/trains may have unavailability higher than 1E-2, but they are treated in

a manner similar to other trains with lower unavailability in the range of $1E-2$. In this screening approach, this is considered adequate to keep the process simple. An exception is made for steam-driven components which are designated as automatic steam driven (ASD) train with a credit of 1, i.e., an unavailability in the range of $1E-1$.

4. Treating passive components (of high reliability) same as active components:

Passive components, namely isolation condensers in some BWRs, are credited similar to active components. The reliability of these components are not expected to differ (from that of active components) by more than an order of magnitude. Pipe failures have been excluded in this process except as part of initiating events where appropriate frequency is used. Accordingly, a separate designation for passive components was not considered necessary.

5. Defining credits for operator actions:

The operator's actions modeled in the worksheets are categorized as follows: operator action=1 representing an error probability of $5E-2$ to 0.5; operator action=2 representing an error probability of $5E-3$ to $5E-2$; operator action=3 representing an error probability of $5E-4$ to $5E-3$; and operator action=4 representing an error probability of $5E-5$ to $5E-4$. Actions with error probability > 0.5 are not credited. Thus, operator actions are associated with credits of 1, 2, 3, or 4. Since there is large variability in similar actions among different plants, a survey of the error probability across plants of similar design was used to categorize different operator actions. From this survey, similar actions across plants of similar design are assigned the same credit. If a plant uses a lower credit or recommends a lower credit for a particular action compared to our assessment of similar action based on plant survey, then the lower credit is assigned. An operator's action with a credit of 4, i.e., operator action=4, is noted at the bottom of the worksheet; the corresponding hardware failure, e.g., 1 multi-train system, is defined in the mitigating function.

6. Difference between plant-specific values and SDP designated credits for operator actions:

As noted, operator actions are assigned to a particular category based on review of similar actions for similar design plants. This results in some differences between plant-specific HEP values and credit for the action in the worksheet. The plant-specific values are usually noted at the bottom of the worksheet, when available.

7. Dependency among multiple operator actions:

IPEs or PRAs, in general, account for dependencies among multiple operator actions that may be applicable. In this SDP screening approach, if multiple actions are involved in one function, then the credit for the function is designated as one operator action considering the dependency involved.

10. Crediting late injection (LI) following failure of containment heat removal (CHR), i.e., suppression pool cooling:

Following successful high or low pressure injection, suppression pool cooling is modeled. Upon failure of suppression pool cooling, containment venting (CV) is considered followed by late injection. Late injection is credited if containment venting is successful. Further, LI is required following CV success. The suction sources for the LI systems credited are different from the suppression pool. HPCI, LPCI, and CS are not credited in late injection. No credit is given for LI following failure of CV. The survival probability is low and such details are not considered in the screening approach here.

9. Combining late injection (LI) with low pressure injection (LPI) or containment venting (CV):

In some modeling approaches, LI is combined with LPI or CV. In the SDP worksheet approach here, these functions are separate. As discussed above, LPI and LI use different suction sources, and CV and LI may be two different categories of operator actions. In these respects, for some plants, SDP event trees may be different than the plant-specific trees.

10. Crediting condensate trains as part of multiple functions: power conversion system (PCS), low pressure injection (LPI), and late injection (LI):

Typically, condensate trains can be used as an LPI and LI source in addition to its use as part of the power conversion system. However, crediting the same train in multiple functions can result in underestimation of the risk impact of an inspection finding in the SDP screening approach since it does not account for these types of dependencies in defining the accident sequences. To simplify the process and to avoid underestimation, condensate train is not credited in LPI, but may be credited in LI.

11. Modeling vapor suppression success in different LOCA worksheets:

Vacuum breakers typically must remain closed following a LOCA to avoid containment failure and core damage. Some plants justify that vapor suppression is not needed for SLOCA. These sequences typically have low frequency and are not among the important contributors. However, an inspection finding on these vacuum breakers may make these sequences a dominant contributor. Accordingly, success of vapor suppression is included in the SDP worksheets. It is included for all three LOCA worksheets (LLOCA, MLOCA, and SLOCA); for plants presenting justification that they are not needed in a SLOCA appropriate modifications are made.

12. ATWS with successful PCS as a stable plant state:

Some plants model a stable plant state when PCS is successful following an ATWS. Following our comparison of similarly designed plants, such credits are not given.

13. Modeling different EDG configurations, SBO diesel, and cross-ties:

Different capabilities for on-site emergency AC power exist at different plant sites. To treat them

consistently across plants, they are typically combined into a single emergency AC (EAC) function. The dedicated EDGs are credited following the standard convention used in the worksheets for equipment (1 dedicated EDG is 1 train; 2 or more dedicated EDGs is 1 multi-train system). The use of the swing EDG or the SBO EDG requires operator action. The full mitigating capability for emergency AC could include dedicated Emergency Diesel Generators (EDG), Swing EDG, SBO EDG, and finally, nearby fossil-power plants. The following guidelines are used in the SDP modeling of the Emergency AC power capability:

1. Describe the success criteria and the mitigation capability of dedicated EDGs.
2. Assign a mitigating capability of "operator action=1" for a swing EDG. The SDP worksheet assumes that the swing EDG is aligned to the other unit at the time of the LOOP (in a sense a dual unit LOOP is assumed). The operator, therefore, should trip, transfer, re-start, and load the swing EDG.
3. Assign a mitigating capability of "operator action=1" for an SBO EDG similar to the swing EDG. Note, some of the plants do not take credit for an SBO EDG for non-fire initiators. In these cases, credit is not given.
4. Do not credit the nearby power station as a backup to EDGs. The offsite power source from such a station could also be affected by the underlying cause for the LOOP. As an example, overhead cables connecting the station to the nuclear power plant also could have been damaged due to the bad weather which caused the LOOP. This level of detail should be left for a Phase 3 analysis.

14. Recovery of losses of offsite power:

Recovery of losses of offsite power is assigned an operator-action category even though it is usually dominated by a recovery of offsite AC, independent of plant activities. Furthermore, the probability of recovery of offsite power in "X" hours (for example 4 hours) given it is not recovered earlier (for example, in the 1st hour) would be different from recovery in 4 hours with no condition. The SDP worksheet uses a simplified approach for treating recovery of AC by denoting it as an operator action=1 or 2 depending upon the HEP used in the IPE/PRA. A footnote highlighting the actual value used in the IPE/PRA is provided, when available.

15. Mitigation capability for containment heat removal:

The mitigation capability for containment heat removal (CHR) function is considered dominated by the hardware failure of the RHR pumps. The applicable operator action is categorized as an operator action with a credit 4, i.e., operator action=4. For this situation, the function is defined as 1 multi-train system since the operator action involved is considered routine and reliable, and is assigned a credit of 4. No other operator action in the worksheets is generically assigned this high credit.

16. Crediting CRD pumps as an alternate high pressure injection source:

In many plants, CRD pumps can be used as a high pressure injection source following successful operation of HPCI or RCIC for a period of time, approximately 1 to 2 hours. In some plants, CRD system is enhanced where it can be directly used and does not need the successful operation of other HPI sources. In the worksheets, if the CRD pumps require prior successful operation of HPCI or RCIC as a success criteria, then CRD is not credited as a separate high pressure injection source. If the CRD can be used and does not require successful operation of HPCI or RCIC, then it is credited as a separate success path within the HPI function.

2.2 RESOLUTION OF PLANT-SPECIFIC COMMENTS

Hope Creek Generating Station was one of the pilot plants in the risk-informed inspection project. Plant-specific comments were received on the notebook developed for the plant during the pilot phase. A summary of the comments that are addressed in developing this version of the notebook is presented below.

- In different transient and LOCA worksheets, the LPI mitigation capability does not include a condensate pump. The condensate train is credited as an LI function. It is recognized that the PCS maybe unavailable for booster/feedwater pumps but may still have low pressure injection capability. However, for the simplified modeling approach such distinctions can not be made and consistent with general assumptions, LI mitigation capability includes condensate trains, but the LPI mitigation capability does not.
- The licensee suggested that the success criteria for LI should also include 1/2 core spray trains; 1/4 LPCI trains; 2/2 condensate transfer pumps and a MD or diesel fire water pump; 2/2 control rod drive pumps (not 1/2). (PRA pages 3.1-10 & 3.1-25). The LI success criteria are modified to include those consistent with the PRA. Using the general assumptions discussed in Section 2.1, LPCI and LPCS trains are not credited as part of LI. 2/2 CRD pumps are not credited for SLOCA. In MLOCA, firewater, condensate transfer pump etc. are not credited because of harsh conditions and leak rate.
- The PRA says that for a normal transient, plenty of time exists to vent containment (33 hrs.) In other scenarios, less time is available. The PRA uses a standard operator error probability of 2.0E-3. Considering this estimation and other plants of similar design, this function is assigned a credit 2 for operator action.
- Consistent with the PRA, the SDP worksheets indicate that only the A & B RHR pumps can be used for SPC. The RHR cross-ties between the A/C and B/D pumps are not modeled..
- SLOCA worksheet has been modified to include the sequence SBLOCA*PCS*LPI. It is among the dominant sequences in the PRA and is based on the reasoning that the ability to spin the HPI turbines will be lost at some point when the reactor is depressurized and LPI will be needed.
- The success criteria for SRVs is considered 2/14 based on the current success criteria used in the IPE, except for medium LOCA. In medium LOCA, the success criterion is 1/14.
- In a loss of offsite power scenario, Salem Unit 3 (gas turbine) is credited as an emergency power source. This is a new addition to the licensee's PRA. The gas turbine requires manipulations from Salem to connect to HC. In addition, if the outside switchyard is lost, the gas turbine can not be connected. Considering the manipulations involved, a credit of 1 is given for the operator action.

- The EDG success criteria in a LOOP is corrected to 2/4 (from 1/4) based on licensee comments.
- The SLC function in the ATWS worksheet includes both maintaining level and initiating SLC. Since this plant has automatic SLC initiation, this function is defined with an operator action credit of 2.. The SLC failure probability in the PRA is $\sim 1.2E-2$.
- In the ATWS worksheet, the INH definition is revised to “operator inhibits ADS and core spray HPCI path”.

REFERENCES

1. NRC SECY-99-007A, Recommendations for Reactor Oversight Process Improvements (Follow-up to SECY-99-007), March 22, 1999.
2. Public Service Electric and Gas Company, "Hope Creek Generating Station Individual Plant Examination", April 1994.