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SUBJECT: RESULTS OF THE HOPE CREEK GENERATING STATION SDP  
PHASE 2 NOTEBOOK BENCHMARKING VISIT

During June, 2002, NRC staff and a contractor visited the Salem/Hope Creek Nuclear Stations site to compare the Hope Creek Generating Station (HCGS) Significance Determination Process (SDP) Phase 2 notebook and licensee's risk model results to ensure that the SDP notebook was generally conservative. HCGS's PSA did not include external initiating events; and therefore, no sensitivity studies were performed to assess the impact of these initiators on SDP color determinations. In addition, the results from analyses using the NRC's draft Revision 3i Standard Plant Analysis Risk (SPAR) model for HCGS were also compared with the licensee's risk model. The results of the SPAR model benchmarking effort will be documented in a separate a trip report to be prepared by the Office of Nuclear Regulatory Research.

In the review of the HCGS SDP notebook, it was found that some changes to the SDP worksheets were needed to reflect how the plant is currently designed and operated. Twenty-six hypothetical inspection findings were processed through the Rev. 0 SDP notebook, and the twenty-six hypothetical cases were processed after changes were made to the worksheets. Results from this effort indicated that the total risk impacts modeled in the Rev. 0 SDP notebook were underestimated by 0 percent, overestimated by 46 percent, and adequately estimated by 54 percent. The reviewers found that if eight fixes, including the changes to operator action credits for the loss of offsite power (LOOP) and loss of instrument air (LOIA) worksheets, were made to the SDP notebook, the results would be 4 percent underestimation, 23 percent overestimation, and 73 percent adequate estimation of risk impacts.

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Attachment A describes the process and results of the comparison of the HCGS SDP Phase 2 Notebook and the licensee's PSA.

If you have any questions regarding this effort, please contact See-Meng Wong.

Attachments: As stated

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**SUMMARY REPORT ON BENCHMARKING TRIP FOR  
HOPE CREEK GENERATING STATION (June 3-6, 2002)**

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# 1. INTRODUCTION

A benchmarking of the Risk-Informed Inspection Notebook for Hope Creek Nuclear Generating Station (HCGS) was conducted during a plant site visit on June 3-6, 2002. NRC staff (J. Trapp and S. Wong) and BNL staff (P. Samanta) participated in this Benchmarking exercise.

In preparation for the meeting, BNL staff reviewed the SDP notebook for the Hope Creek Generating Station and evaluated a set of hypothetical inspection findings using the Rev. 0 SDP worksheets. In addition, NRC staff provided the licensee with a copy of the meeting protocol.

The major milestones achieved during this meeting were as follows:

1. Recent licensee's modifications to the HCGS PRA model were discussed for consideration in preparing the Rev. 1 notebook for the plant.
2. Importance measures, including the Risk Achievement Worths (RAWs) for the basic events in the internal event model for average maintenance, were obtained from the licensee.
3. Benchmarking was conducted using the Rev. 0 SDP model and the revised SDP model considering the licensee's input and other modifications that were judged necessary based on comparison of the SDP model and the licensee's detailed model.
4. For cases where the color evaluated by the SDP notebook differed from that determined based on the RAW values generated by the updated licensee's PRA, results of the licensee's model including the detailed minimal cutsets were requested from the licensee. The cutsets were reviewed to understand the reason for the differences. Applicable changes were defined for the SDP model.

Following the modification to the Rev. 0 SDP notebook for Hope Creek, a comparison of results between the notebook and the plant's PRA model shows 1 case of underestimation (by one color) and 6 cases of overestimation (1 by two colors, and 5 by one color) out of 26 hypothetical cases studied. Similar colors are obtained for the remaining 19 cases. In another words, in 25 out of 26 cases, the notebook provides comparable, similar or conservative results by one color, and in 1 out of 26 cases, it shows a non-conservative result. Using the Rev. 0 notebook would have resulted in 12 cases of overestimation (4 by two colors and 8 by one color) out of the 26 cases studied. In summary, benchmarking has identified modifications which improve the matches (similar results) from 54% to 73%, reduce overestimation from 46% to 23%, but increase underestimation from 0% to 4%.

## 2. SUMMARY RESULTS FROM BENCHMARKING

This Section describes the results of the benchmarking exercise. The results are summarized in Table 1. Table 1 consists of six columns. The first column identifies the components or the case runs. The colors obtained using the SDP Rev. 0 worksheets without incorporating any modification from the benchmarking exercise are shown in the second column. The third column shows the internal RAW and the fourth column shows the associated colors estimated based on the licensee's RAW values from the latest PRA model. The fifth column presents the colors for the inspection findings based on the revisions of the SDP Rev. 0 worksheets judged applicable during benchmarking. The last column provides comments explaining the differences between the SDP's and the plant's PRA colors.

The colors obtained for inspection findings using the revised SDP notebook are observed to be underestimated in 1 case and overestimated in 6 cases out of the 26 cases studied. Conservative results are expected since the SDP model is a simplified tool and is intended to provide conservative colors. However, the reason for the differences is analyzed using the minimal cutsets for the cases where differences in colors are observed. These cases are discussed below.

Underestimation was noted for the HPCI pump. The reason for this underestimation is analyzed as follows:

1. The initiating event (IE) frequencies for transients with loss of PCS (TPCS), Stuck-open relief valve (SORV), and medium LOCA (MLOCA) are higher compared to the estimates used in the SDP notebook. The IE frequencies are respectively 0.5, 5E-02, and 9.3E-04 per reactor-yr. Comparable frequencies in the SDP notebook are 1E-01, 1E-02, and 1E-04 per reactor-yr. For the HPCI pump, the sequences obtained from the notebook and the PRA are same, but the differences in the IE frequency contribute to the underestimation.

Overestimation is noted in six cases: 1 SLC pump, 1 SSW train, 1 AC Bus, operator fails to use PCS, operator fails to vent, and operator fails to inhibit high pressure injection in ATWS. The reasons for these overestimations are discussed below.

1. The overestimation of the standby liquid control (SLC) pump is largely attributed to the difference in the ATWS frequency. The ATWS frequency used in the licensee's PRA is approximately a factor of 20 lower compared to the estimate used in the SDP notebook.
2. Overestimation for 1 SSW train can be related to the licensee's assumption of recovery of loss of service water with a probability of 0.1. Recovery credit is not provided in the SDP notebook; recovery credit will be judged as part of the inspection finding.
3. Overestimation for the loss of 1 AC bus is also related to the assumption used in counting the loss of SW sequences. In the SDP estimation LOSW frequency is increased an order of magnitude and also no recovery credit is given.
4. Overestimation of operator failing to use PCS is due to lower estimates used for suppression pool cooling (CHR in the notebook) and the late inventory makeup in the plant's PRA.

5. Overestimation for the operator failing to inhibit is due to the differences in the ATWS frequency discussed earlier.
6. Overestimation for the operator failing to vent is due to a lower estimate used for suppression pool cooling used in the plant's PRA and the use of recovery factor of 0.1 in loss of service water (LOSW).



**Table 1. Comparison Table for Hope Creek Benchmarking**  
**CDF = 8.661E-6/yr, W = 1.115 (RAW), Y = 2.155 (RAW), R = 12.55 (RAW)**

No.	Basic Event Name	Before	RAW	Plant CDF Color	After	Comments
1.	RCIC	R (O)	5.28	Y	Y	
2.	HPCI	R	14.2	R	Y	Underestimation; higher initiator frequencies for TPCS, SORV, and MLOCA in the licensee's PRA contribute to higher RAW for licensee.
3.	One SRV FTC	Y	2.16	Y	Y	
4.	1 LPCS train	G	1.0	G	G	
5.	MS/FW	G	NA	G	G	
6.	1 condensate pump	G	NA	G	G	
7.	1 RHR train (not A or B)	G	1.0	G	G	
8.	RHR pump A or B	R (O)	2.29	Y	Y	Match for RHR pump B; conservative for RHR pump A. (See Note 1.)
9.	1 CRD pump	W (O)	1.0	G	G	
10.	1 Cond. transfer pump	Y (O)	1.0	G	G	
11.	1 SLC pump	G	1.06	G	Y	Overestimation by 2 colors. Licensee's ATWS frequency is a factor of 20 lower than the SDP frequency.
12.	IA (one compressor fails)	Y (O)	1.03	G	G	

No.	Basic Event Name	Before	RAW	Plant CDF Color	After	Comments
13.	1 Fire pump	Y (O)	1.0	G	G	
14.	1 EDG	W	1.64	W	W	
15.	2 EDGs	W	1.64	W	W	
16.	Salem gas turbine	W	1.19	W	W	
17.	1 SSW train	Y (O)	1.43	W	Y	Overestimation; Licensee assumes loss of SW can be recovered with 0.1 likelihood.
18.	Containment venting path	Y (O)	1.39	W	W	
19.	1 AC Bus	R (O)	11.4	Y	R	Overestimation; from SW train.
20.	1 DC Bus (250 VDC Bus A)	R	14.20	R	R	
<b>Operator Actions</b>						
21.	Operator fails to CV	R	2.39	Y	R	Overestimation; credit for SPC (i.e., CHR function in the notebook) is conservative in the notebook.
22.	Operator fails to DEP	R	494.21	R	R	
23.	Operator fails to use PCS	W (O)	1.04	G	W	Overestimation; SDP is conservative in crediting SPC.
24.	Operator fails to CHR	R		R	R	
25.	Operator fails to INH	Y (O)	1.29	W	Y	Overestimation; due to differences in ATWS frequency.

No.	Basic Event Name	Before	RAW	Plant CDF Color	After	Comments
26.	Operator fails to use condensate train in M/LLOCA	W (O)	1.0	G	G	

Note 1. In the Hope Creek plant, for loss of buses A and D, containment venting is lost. In those situations, operator can open the valve using hand-wheels from a remote control station. The human error probability (HEP) for this action is 0.1. For failure of RHR pump B, RHR pump A can be lost due to the loss of bus A and containment venting is conducted from remote control station. The combined credit of the remaining RHR train and the operator failing to vent (HEP = 0.1) in the notebook is comparable to that in the PRA. In case of the RHR pump A, a loss of bus B does not require manual action from the remote control station, and the combined credit of the remaining RHR train and the operator failing to vent in the notebook is conservative compared to the plant's PRA. The notebook does not distinguish these differences and provides a conservative estimate for RHR pump A.

**Table 2: Comparative Summary of the Benchmarking Results**

Comparisons	Rev. 0 SDP Notebook		Rev. 1 SDP Notebook implementing the changes identified	
	Total Number of Cases=26			
	Number of Cases	Percentage	Number of Cases	Percentage
SDP: Less Conservative	0	0	1	4
SDP: More Conservative	12	46	6	23
SDP: Matched	14	54	19	73

### 3. PROPOSED MODIFICATIONS TO REV. 0 SDP NOTEBOOK

A set of modifications were proposed for the Rev. 0 SDP notebook as a result of the site visit. These proposed modifications are based on the licensee's revision to the plant's PRA, better understanding of the current plant design features, revised Human Error Probabilities (HEPs), modified initiator frequencies, and the results of benchmarking.

#### 3.1 Specific Changes to the Rev. 0 SDP Notebook for Hope Creek Generating Station

Several modifications have been identified for the Rev. 0 notebook based on the benchmarking at the plant. A summary of the major changes is provided below.

1. Table 1 is modified based on the plant-specific frequency of the special initiators. Loss of Instrument Air (LOIA) frequency is  $1.6E-04$ /reactor-yr and is moved to Row IV. It is noted in a footnote that MLOCA and SLOCA frequencies are respectively  $9.3E-04$ /reactor-yr and  $6.5E-04$ /reactor-yr, i.e., MLOCA frequency is higher than SLOCA frequency.
2. Operator action credit for depressurization (DEP) is changed from 2 to 3. Revised estimate for the human error probability (HEP) in the plant's PRA is  $1.0E-03$ . In ATWS, an operator action credit of 1 is used because the plant-specific HEP is  $5.6E-02$ .
3. Credit for Late Inventory, Makeup (LI) is changed from operator action = 2 to operator action = 3. Multiple options exist and the HEPs associated with these actions are low.
4. The description of LPCS mitigation capability is changed to state "1/4 LPCS pumps in 2 trains" in all applicable worksheets.
5. At Hope Creek, the valves in the 12" Hard Pipe Containment Venting System and in the 6" hard pipe line can be operated from a remote control station using hydraulic hand pumps without any dependency on air or power. In the LOIA worksheet, containment venting is modified to be conducted from the remote control station. An operator action credit of 1 is assigned based on the Hope Creek HEP of 0.1 for this action.
6. In the LOOP worksheet, the operator action credit for recovery of offsite power in 5 hrs. is changed from 2 to 1. The non-recovery probability in the PRA is  $5.6E-02$ .
7. For loss of buses A and D, containment venting is lost. Operators can open the valves using hand-wheels from a remote control station. A footnote is provided so that operator action credit for containment venting can be adjusted for buses A and D.
8. In the ATWS worksheet, 2/2 SLC pumps success criteria is explicitly included.

### **3.2 Generic Change in 0609 for Inspectors**

None identified.

### **3.3 Generic Change to the SDP Notebook**

None identified.

#### **4. DISCUSSION ON EXTERNAL EVENTS**

Integrated external event PRA model was not available for the Hope Creek plant. No evaluations were conducted for the external event risk during the benchmarking exercise.

## 5. LIST OF PARTICIPANTS

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Pranab Samanta	BNL
James Trapp	USNRC/Region I
See-Meng Wong	USNRC/NRR
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