Throughout the design process, the PRA plays an important role both in identifying features that merit consideration with respect to opportunities to reduce risk, and to review proposed design changes to evaluate the potential risk impact. As indicated earlier, PRA review of design changes is incorporated into the AREVA NP design change control process.

AREVA NP has also used insights from the PRA to identify specific improvements to reduce the contribution to risk due to some aspects of the design. The specific areas of improvement include the following:

19.1.3.4.1 SBO Diesel Generators

The SBO diesel generators were added to reduce the contribution of SBO events initiated by a LOOP. The PRA also identified the need for the SBO diesel generators to be independent and diverse from the EDGs. To that end, the SBO diesel generators differ from the EDGs in manufacturer, control logic, starting and control batteries, fuel oil, cooling mechanism, and location.

19.1.3.4.2 Cooling of Low Head Safety Injection Pump Motors

Cooling water for the motors for two of the four low head safety injection (LHSI) pumps (Pumps 1 and 4) were permanently aligned to the safety chilled water system (SCWS). The original configuration entailed cooling of all four pumps by the component cooling water system (CCWS), with chilled water available as backup cooling to pumps 1 and 4. This change added diversity in the motor cooling and eliminated the need for manual alignment of backup cooling. Since Divisions 1 and 4 of the chilled water system are air cooled, the diversity extends to the heat sink used for cooling. The change in configuration also eliminates the potential that common cause failure (CCF) of the three-way valves supplying cooling water could affect two of the LHSI pumps.

~~19.1.3.4.3 Reliability of Safety Injection Actuation During Mid-Loop Operation~~

~~A diverse signal consisting of LHSI residual heat removal (RHR) pump low suction pressure has been added to actuate the MHSI pumps to reduce the potential for over-draining the RCS during mid-loop operation. Thus, MHSI is actuated on either low level in the RCS loops or LHSI/RHR pump low suction pressure.~~

19.1.3.4.3 Increased Diversity of Cooling Water for the SAHRS

As noted in Section 19.1.3.2, the SAHRS is available for containment heat removal and other functions in the long term after an accident. To provide further diversity with respect to the systems whose failure could lead to core damage, cooling for the SAHRS heat exchanger is achieved via a dedicated train of component cooling water (CCW) and emergency service water (ESW).

presented in the table. The overall result is an increase by approximately 15 times in the CDF to 5E-6/yr, still well below the NRC goal of 1E-4/yr.

The CDF results were not sensitive to the assumption on mission time for long term cooling, or on the assumptions about isolation of the EFW tanks leaks.

A simple sensitivity analysis (not reported in Table 19.1-15) was performed for the ISLOCA events, using mean values for the ISLOCA IE frequencies, versus point estimates. Since ISLOCA event contribution to the CDF is negligible, the effect of this change on the CDF was also negligible (less than one percent).

Table 19.1-15 shows only moderate improvements in CDF if some design changes are considered, or less conservative assumptions are made. The one design change which may be considered in the future (~~16~~ 7 percent improvement) is to realign MSRIVs so that they would not require two electrical divisions for their operation.

19.1.4.1.2.7 Uncertainty Analysis

Uncertainty on the Level 1 Internal Events PRA results is quantified using the built-in uncertainty analysis capabilities of Risk Spectrum. This PRA uncertainty quantification evaluates parametric uncertainty. Modeling uncertainty is addressed with limited scope in a separate uncertainty evaluation.

Parametric uncertainty was quantified by selecting an uncertainty distribution for each input parameter. Distributions mostly applied are Lognormal, Beta and Gamma, as described below for each type of parameter:

- Initiating Events: Uncertainty distributions were obtained from the same source as the mean values. For initiating events evaluated by fault trees, lognormal distribution was fit to the uncertainty distribution obtained from the RS run. Exceptions are IE frequencies for flooding and fire events, which are based on limited information, and, for their modeling, a constrained non-informative distribution (CNI) was used. This will be discussed in the corresponding sections for internal fire and floods.

- Failure Rates: Uncertainty distributions were obtained from the used data source.

- Digital I&C Failure Rates: Lognormal distribution was used, an error factor of five was estimated from upper & lower confidence bounds in TXS documentation.

- Common Cause Parameters: Uncertainty parameters were obtained from the same source as CC factors. They were fit to lognormal distribution and only applied to the "beta" factor.

- LOOP Related Basic Events: Gamma distribution for LOOP frequency, with upper and lower bounds, was fit to various LOOP events (consequential LOOPs and LOOP in 24 hours).