This synopsis provides an overview of each portion of the 2006 update to the Cook plant internal flooding PRA model. It lists each calculation or report associated with the update and provides a brief description of their purpose and additional information about techniques, methods, or criteria if warranted. All were calculations or reports generated in accordance with the Cook calculation process, utilizing an independent review.

PRA-FLOOD-001 assessed risk associated with fire water piping located in each Units Train A, DC distribution panel area. The condition was noted during the flooding walkdowns in preparation for the entire flooding update. Risk was assessed using industry generic values for piping and valve rupture frequency, combined with flooding scenario development relying on plant physical characteristics, expected impact on associated plant equipment, and expected personnel responses. This calculation provided impetus for minor modification to use RTV to seal an electrical panel in each unit. This calculation addressed piping that was not in the plant when the original IPE flooding evaluation was performed.

PRA-FLOOD-002 provides a qualitative assessment of internal and external flooding on the Cook Electric Power distribution for both units. It discusses the offsite power sources and the potential for external flooding. It also reviewed the internal distribution systems, and the potential for internal floods to affect the distribution and in-plant emergency power supplies (e.g., EDGs), and cause plant transients. This includes plant features and expected scenarios for internal flooding conditions. Plant design features, such as openings, curbs, walls, etc, and electrical distribution system protective features are discussed.

PRA-FLOOD-003 quantitatively evaluated rupture of condensate/feedwater piping in the turbine building and its impact on the Cook units electrical distribution system. It utilized information from the plant walkdown regarding building features and equipment layout, expected scenario development and consideration of personnel actions, as well as generic industry pipe and component rupture frequencies, and the then current PRA model to assess the impact on plant CDF.

The specific methodology [sumarized from the calculation] was to develop a flood scenario for a feedwater line rupture in the turbine building by examining potential propagation paths, giving credit for appropriate flood mitigation systems or operator actions, and identifying susceptible Structures, Systems and Components (SSCs). Assess damage to equipment in the local vicinity that may occur immediately due to spray. Look for equipment damage due to critical equipment flood levels for a flood of reasonable size. Consider flood propagation to adjacent zones that may or may not occur until the flood level rises above a curb or other physical barrier, and estimate additional time before the level reaches a critical height in the affected zone(s). Define a set of distinct Flood Damage States (FDS), each corresponding to height of flooding with a progressively increasing severity of equipment loss. For each flood source, a FDS will be assigned. The Conditional Core Damage Probability (CCDP) of each of the FDSs was determined using WinNUPRA, and the CCDPs are multiplied by the endstate probabilities from the flood growth event tree.

PRA-FLOOD-004 involved an evaluation of all flood areas to identify potential flooding sources, propagation paths, and equipment that may be adversely affected due to the accumulation of water, spray, dripping, and steam damage. The study's scope did not include occurrence of flooding events in which a plant trip or requirement to shut down does not occur since the PRA only addresses events following plant trips or forced shut downs. Floods that caused economic losses without an accompanying plant trip were also beyond the scope of the study. Additionally, flooding events in which accident mitigating equipment was not disabled are considered to be no different than plant transients. Transients are addressed elsewhere in the PRA.

The ASME Standard for Probabilistic Risk Assessment for Nuclear Power Plant Applications, Draft Addenda B to ASME RA-Sa-2003 was used as the overall analysis standard for the flooding update.

PRA-FLOOD-005 calculated rupture frequency of piping that could contribute to internal flooding for use in the Internal Flooding PRA update. This calculation used select design inputs and other information for these calculations. The pipe rupture rates were taken/developed from/consistent with EPRI TR-102266 [i.e., the "Jamali" method of pipe segments].

PRA-FLOOD-006 estimated flow rates of water release and the capacity of the source for various flood areas assumed in the DC Cook internal flooding PRA Model. The calculation did not address the characterization of the breach (e.g., leak, rupture, spray) and form (e.g., a five- foot cone-shaped spray discharging to the northeast). The calculation provided data for equipment immersion and flood propagation analysis. Design Inputs specific for each system and or flood area were used and listed in the text of the calculation subsections. In some cases, the source flow estimate for some system pressures and temperatures came from training material, or real time values from the plant were used. The training material in some cases was the most realistic information available. Data taken from this training material is properly referenced and traceable to source diagrams.

PRA-FLOOD-007 calculated idealized Flood Area floor drain system flow rates for Flood Areas that were not scoped "out of concern" for the DC Cook Internal Flood PRA analysis. The calculation provided data regarding mitigation pathways, or flooding pathways (for drain backflow) for equipment immersion and flood propagation analysis for the DC Cook Internal Flood PRA update.

PRA-FLOOD-008 identifies flood sources internal to Units *1* and 2 of the Cook Nuclear Power Plant. The subtasks included:

a) Identify flood sources in each flood area, i.e., determine the number of pipe segments, valves, pumps, tanks, heat exchangers, and expansion joints.
b) Determine flooding mechanisms associated with each flood source.
c) Determine characteristic of each flooding mechanism.
d) Identify drains and sumps of each flood area and determine capacity of the mitigation features.

Flood sources in each flood area were determined based on current plant drawings and plant walkdowns. For each source and its identified failure mechanism, the characteristic of water release and the capacity of the source were identified. These include:

a) characterization of the breach, including type (e.g., leak, rupture, spray),
b) flow rate of water, and,

c) capacity (e.g., gallons of water source).

In each flood area, any floor drains (i.e., any physical structure that can function as a drain) or sumps (i.e., any physical structure that allows for the accumulation and retention of water) were identified. The capacity of drains and the amount of water retained by the sumps were determined. If these are larger than a flood source in the area and the flood source cannot cause additional equipment damage or failure based on ASME IF-C3 and IF-C4, then the flood source may be eliminated. The work was conducted in accordance with ASME Index No. HLR-lF-B for Capability Category II.

PRA-FLOOD-009 estimated geometric size (floor area and volumes) of Flood Areas that were described in PRA-FLOOD-004. The estimates are for detailed assessment of different volumes in the submergence analysis in the Cook Flooding PRA update. Flood Area configuration has been determined by using Flood Areas description in PRA-FLOOD-004 and the existing plant Fire Hazard Analysis Drawings. Dimensions were taken from detailed Plan Drawings, or scaled from drawings if no better information was available. The areas were calculated using elementary algebraic formulas for area and volume.

PRA-FLOOD-010 estimated timing as to when water level reached critical flood height for various flood sources and compartments. This information was used to screen out some flood sources if it was determined that sufficient time exists for flood detection and isolation. The results were also used to determine failure to isolate probabilities for the flood growth event trees for DC Cook Internal Flood PRA. General assumptions used in this calculation were:

3.1 Transport time for water flow from upper elevations, or within boundaries of one Flood Area were not taken into account. The propagation was assumed to be instantaneous.
3.2 Constant flow rates from the ruptures were assumed.
3.3 Additional assumptions were presented for each specific system.

PRA-FLOOD-011 qualitatively generated flood scenarios used in performing a detailed analysis of unscreened areas and sources of plant internal flooding. These were developed considering:

- flood sources within the area,
- propagation paths out of area,
- impacted SSC's,
- resulting initiating event(s),
- area mitigation features, and,
- interfacing propagation paths into the area.

PRA-FLOOD-012 is a structured, systematic assessment consistent with the ASME PRA Standard to identify those flood scenarios challenging normal plant operation and requiring successful mitigation to prevent core damage. For identified areas progressive screening analysis were conducted starting with the initial quantification of gross flood frequencies. For areas/scenarios not quantitatively screened, analysis was refined to develop flood frequency vs. flow rate relationships. Loss of the flood source and flood susceptible SSCs in a given flood area were examined for impact on normal plant operation. Inter-area propagation was considered as discussed above. The potential for flooding induced transients or LOCAs was included in the assessment.

In searching for flood-induced initiating events, the impact of plant-specific initiating event precursors and system alignments was reviewed, including the alignments of supporting systems.

From information contained in the Flood Scenario Table, normal system alignments, and any available information from the existing Level *I* initiating event task and discussion with plant personnel, the initiating events arising from each of the flood scenarios were identified.

Consistent with ASME PRA Standard Supporting Requirement IFC, flood scenarios were developed by examining potential propagation paths, giving credit for appropriate flood mitigating systems or operator actions, and identifying susceptible SSCs. In developing the flood scenarios, relevant information, which would form the boundary conditions for interfaces with the internal events PRA, was collected (affected flooding area, source, flood rate and source capacity, initiating event(s), operator actions, SSC damage) to meet Supporting Requirements, IF-D3, IF-D3a, and IF-D4, of the ASME Standard.

The internal flood sources and flood groups were screened based on ASME PRA Standard supporting requirements IE-C4, IF-C5, IF-C6, IF-C7, IF-C8, IF-D7, and IF-E3a.

NOTE -- due to an oversight, the PRA-FLOOD-013 calculation (below), completed in June 2006, is not yet in Documentum, the Cook controlled document repository, but is currently being processed for addition.

PRA-FLOOD-013 qualitatively characterized and quantified the Human Error Probability (HEP) associated with the operator actions following a flood initiating event, typically in the Auxiliary Building or the Turbine Building. HEPs were quantified for floods in the following systems,

- CCW
- ESW
- NESW
- Primary water or demineralized water
- Large breaks in circulating water piping

Assumptions/information used to develop the HEPs were as follows:

1. Initial Conditions: Steady state, full power operation. (This was the same for each action since this is the scope of this analysis – internal flooding events during full power operations.)

2. Initiating Event: The initiating event in each case was an internal flood. In some cases this is modeled as a pipe rupture of the specific system, in other cases this is system leakage, and in some cases spray.

3. Accident Sequence: This is the plant progression following the initiating event, documenting the functional and/or system successes and failures that define the modeled scenario.

4. Operator Action Success Criteria: Each task that the operator must perform correctly in order to isolate the rupture was identified and evaluated quantitatively.

5. Assumptions: This section documents the identification of assumptions specific to each HFE

HEP development factors included: cues and indications, procedures and training, timing, and performance shaping factors. The EPRI HRA Calculator® software [Ref. 2] was used for this analysis. The EPRI Calculator employs the methodologies described in EPRI-TR-100259 and THERP from NUREG/CR-1278. Because most of the human failure events associated with flooding were determined to be time critical, P_{cog} was always calculated using Human Cognitive Reliability/Operator Reliability Experiment (HCR/ORE) technique for most cases.

PRA-FLOOD-014 performed detailed analyses of those flood sources and groups that were not screened from further consideration. The report developed the detailed analyses quantifying the frequency of core damage scenarios due to internal flooding during full power operations.

Calculations for flood accumulation rates and time to reach critical flood heights (listed above) were developed and used. Information obtained from these calculations included:

a) critical flood volume for each flood damage state (FDS) to reach the associated critical flood height.
b) water egress and ingress rates from the flood area(s).
c) water accumulation rates in the flood area(s).
d) flood damage timings (i.e., time to reach critical flood heights).

Human reliability analyses (HRA) were performed and included the following scenario-specific performance shaping factors (PSF) for control room and ex-control room actions as appropriate:

a) additional workload and stress (above that for similar sequences not caused by internal floods)
b) uncertainties in event progression (e.g., cue availability and timing concerns caused by flood)
c) effect of flood on mitigation, required response, and recovery activities (e.g., accessibility restrictions, possibility of physical harm)
d) flooding-specific job aids and training (e.g., procedures, training exercises)

Extraordinary recovery actions that are not proceduralized were generally not credited, but if used they were justified (i.e., evidence provided of appropriate training that would ensure knowledge, skill of the craft). The determination of isolation probabilities is part of the HRA effort and was performed.

The model includes the combined effects of failures caused by flooding and those coincident with the flooding due to independent causes including equipment failures, unavailability due to maintenance, and other credible causes. Structures, Systems, and Components (SSC) lost due to flooding were modeled by generating basic event database files specific to the flood damage states.

The model includes both the direct effects of the flood (e.g., loss of cooling from a service water train due to an associated pipe rupture) and indirect effects such as submergence, jet impingement, and pipe whip.

The flooding core damage frequencies were generated by constructing Flood Growth Event Trees for the most dominant flood groups. For those flood groups for which a Flood Growth Event Tree was not constructed, the screening core damage frequency (CDF) value was retained as the bounding value of the contribution to the overall flooding CDF.

The flood growth event trees provide the logic structure for flood propagation and timing. The endstates of the flood growth event trees are flood damage states (FDS). Conditional core damage probabilities (CCDP) were calculated for each of the flood damage states. The frequencies of the flood growth event tree endstates were multiplied by the FDS CCDPs to provide the CDF for each of the flood growth event tree endstates.

Two sources of pipe rupture data were used in the quantification. All of the screening quantification and the first quantification of the detailed analyses were performed using flood frequencies calculated using the methodology in EPRI report TR-102266 "Pipe Failure Study Update", also known as the "Jamali method". In this methodology, piping is divided into pipe sections. A pipe section is defined as a segment of piping between major discontinuities such as valves, pumps, reducers, or tees. A pipe section typically ranges from 10 to 100 feet in length and contains 4 to 8 welds. Each section can also contain several elbows and flanges. Instrumentation connections are not considered major discontinuities. The resulting pipe rupture frequencies using this methodology are a function of rupture size, e.g., frequency of a 2 inch rupture in a 6 inch pipe. The methodology is discussed in greater detail in calculation PRA-FLOOD-005.

After the first detailed quantification, the dominant flood groups of ruptures in the CCW system were re-quantified using pipe rupture frequencies based on pipe length taken from EPRI TR-1013141 "Pipe Rupture Frequencies for Internal Flooding PRAs – Revision 1", also known as the "Fleming method'. The Fleming method is newer than Jamali, but was too new at the time to be used in the quantification of all scenarios since, in the initial preparation of the report, piping data (a considerable amount of information) was collected in the form of pipe segments, and not pipe length.

Additionally, CCW is a low pressure system and the later EPRI report (Fleming method) contained more data and explicitly discusses CCW systems. For these reasons, TR-1013141 frequencies were considered a better fit for the CCW system at Cook.