Oconee Nuclear Site

Spent Fuel Pool Safety Enhancement Backfit Analysis

Duke Power Company

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Executive Summary

By letter dated September 20, 1996, the NRC formally notified Duke Power Company (Duke) that it will be performing backfit analyses pursuant to 10 CFR 50.109(a)(3) regarding two concerns related to Oconee Nuclear Site (ONS) loss of spent fuel pool (SFP) inventory scenarios. The concern is that, since the fuel transfer tubes and connected piping are at an elevation below the top of the spent fuel assemblies, it is conceivable under certain postulated scenarios that the spent fuel could be uncovered. This report documents Duke's analysis of the potential loss of inventory sequences in the SFPs which could lead to possible spent fuel damage.

The report provides an overview of the design features and administrative controls that protect against inadvertent draining of the SFPs. Duke's analysis included an assessment of opportunities for procedure enhancements to minimize human errors which could lead to loss of inventory scenarios. In addition, the review identified procedure changes to improve the ability of the operators to respond to loss of SFP inventory events. The report summarizes procedural changes that Duke will implement as a result of the study.

Duke also evaluated potential modifications to the SFPs to reduce the risk associated with drain down scenarios. These potential modifications included adding standpipes to the SFPs so the transfer tube isolation valves (SF-1 and SF-2) can be closed during normal operation, adding motor operators to SF-1 and SF-2, and installing weir walls in the SFPs. The incremental safety benefit of implementing these modifications has been analyzed by performing a public risk analysis. Duke has attempted to perform the public risk analysis using methods considered comparable to those used by the staff.

Duke's analysis concluded that the probability of an accident sequence due to the low fuel transfer tube elevation leading to sustained fuel uncovery in the Oconee SFP is estimated to be approximately 8.4E-7 per year for the Units 1 and 2 SFP, and 7E-7 per year for the Unit 3 SFP. This probability is much less than the estimated core damage sequences for the plant. The Oconee SFP drain down accident

scenario probability is comparable to the beyond design basis accident probability for typical SFPs as estimated in NUREG/CR-4982.

The public risk analysis estimated the reduction in the sequence frequency associated with implementing each modification, or the averted sequence frequency. The dose consequences for the various SFP loss of inventory scenarios were calculated using a combination of Oconee-specific calculations and data obtained from previous NRC studies. The cost of averted risk associated with each proposed modification is estimated by multiplying the SFP accident frequency reduction by the conditional cost of the accident. Results of the Duke cost benefit analysis for the potential modifications to the SFPs are presented in the following tables.

Units 1 and 2 SFP

Proposed Modification	Averted Sequence Frequency (per year)	Averted Person-Rem (per year, worst case)	Public Benefit (present worth)	Modification Cost (1998 $)
Motor operators for SF-1 and SF-2	1.35E-08	0.1215	$7,089	$950,000
Standpipe	2.98E-08	0.2680	$15,634	$650,000
Weir Wall	2.69E-07	2.4210	$141,294	$1,200,000

Unit 3 SFP

Proposed Modification	Averted Sequence Frequency (per year)	Averted Person-Rem (per year, worst case)	Public Benefit (present worth)	Modification Cost (1998 $)
Motor operators for SF-1 and SF-2	6.75E-09	0.0608	$3,544	$700,000
Standpipe	2.30E-08	0.2072	$12,090	$450,000
Weir Wall	1.43E-07	1.2870	$74,920	$1,000,000

As can be seen from the above table, Duke's analysis concludes that the costs of these modifications to the SFP are not justified when compared to the small reduction in public risk that they would achieve.

However, Duke's study did identify procedural changes that will further reduce the likelihood of human errors that

could lead to loss of SFP inventory events. In addition, procedural enhancements to mitigate loss of SFP inventory events were identified. Duke intends to implement these procedural changes to minimize the risk associated with loss of SFP inventory events.

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1.0 Background

The NRC recently completed an industry review of spent fuel storage pool safety issues. The results of this review were issued in a memorandum to the Commissioners dated July 26, 1996. The NRC review identified potential concerns at a number of operating plants. The NRC report identified the following two concerns regarding the spent fuel pool (SFP) design at Oconee Nuclear Site (ONS):

1) During periods when the blank flange on the containment side of the transfer tube is removed, improper operation of the spent fuel transfer system or the SFP cooling and cleanup system could lead to loss of inventory from the SFP. Since the transfer tubes penetrate the SFP wall at an elevation below the top of the fuel in the storage racks, it is conceivable that the spent fuel could be uncovered.

2) The Standby Shutdown Facility (SSF) Reactor Coolant Makeup System draws suction from the transfer tubes. In addition, Reactor Coolant System letdown is directed back to the SFP via a connection to the transfer tubes when the SSF Reactor Coolant Makeup System is in operation. This configuration introduces the potential for improper alignment of the system or failure of the piping that could result in a loss of SFP inventory, possibly leading to uncovery of the spent fuel.

This report assesses the adequacy of the current design with respect to the above concerns identified in the NRC letter dated September 20, 1996. The report includes an overview of current design features and administrative controls that protect against inadvertent draining of the SFPs. Duke also evaluated relevant procedures and identified some enhancements regarding loss of SFP inventory events. Duke Power's engineering staff estimated the cost of modifying the SFPs to protect against the above drain down concerns. Finally, a value/impact analysis was conducted to estimate the incremental public health risk and cost associated with modifying the SFPs to address the two concerns associated with the fuel transfer tubes. The value/impact analysis considered the current design, proposed modifications, site characteristics, and industry operating experience to estimate the public health risks and costs.

2.0 Design Features

Oconee Nuclear Site has two spent fuel pools. One pool, with a storage capacity of 1312 fuel assemblies, serves Units 1 and 2. The other pool, with a storage capacity of 825 fuel assemblies, serves Unit 3. Each SFP is connected to the fuel transfer canal in the reactor building via transfer tubes. Figure 1 is a three-dimensional illustration of the refueling system. Except during refueling operations, the transfer tubes are isolated from the fuel transfer canal by blank flanges. Isolation valves in the SFP (SF-1 and SF-2) are used to isolate the SFP from the transfer tubes. These valves are open during normal operation to support operability of the Standby Shutdown Facility (SSF).

Each SFP has a Spent Fuel Cooling System (SFCS) composed of combined cooling and purification loops. The cooling loop(s) can be and usually is operated without the purification loop(s). The SFCS consists of three pumps and three heat exchangers connected in parallel loops (see Figure 2). The number of loops in operation depends on the heat load in the pool and the temperature of the coolant entering the heat exchangers. Cooling water to the heat exchangers is provided by the Recirculated Cooling Water System. The purification loop consists of two filters and a demineralizer. The system also includes a borated water recirculation pump that is used in conjunction with the purification loop to clean the borated water in the borated water storage tank (BWST) and SFP.

The cooling loop removes decay heat from the spent fuel in the pool. The cooling loop normally takes suction from a high point in the pool and returns flow to both high and low points in the pool. The cooling loop piping is arranged so that the pool cannot be inadvertently drained to uncover the fuel. There are two cooler discharge lines and two pump suction lines that extend into the pool. Both suction lines and one discharge line extend four feet or less below the normal pool water level of about 840 feet. The top of the fuel assemblies are at an elevation of approximately 816.5 feet. The remaining discharge line has a siphon breaker at 18 feet below the normal water level.

Pool makeup can be provided from the concentrated boric acid storage tank (CBAST), boric acid mix tank, bleed hold-up tank, demineralized water, or the BWST. If, during an accident, all of these makeup sources are unavailable, remote makeup capability can be used by connecting an external makeup line to an external water source (fire trucks, lake water, etc.).

During normal operation, spent fuel cooling water is continuously circulated through the spent fuel pool. Cooling flow is maintained between 800 and 1000 gpm for single spent fuel cooling pump operation or between 1600 and 2000 gpm for two pump operation. After spent fuel cooling flow is adjusted, the spent fuel cooler outlet temperature cooling water control valve is adjusted to maintain pool temperature between 80°F and 110°F.

The SFP water level and boron concentration are controlled by makeup from the demineralized water system, bleed holdup tanks, CBAST, or BWST. The SFP is placed in recirculation, through the purification loop, for 24 hours every week to ensure a representative sample is obtained for boron analysis. To lower pool level, suction is taken from the pool by the borated water recirculation pump and directed to the BWST.

During refueling operations, the spent fuel cooling water is lined up to circulate through the fuel transfer tubes into the fuel transfer canal. The "B" spent fuel cooling pump is lined up to take suction on the fuel transfer canal, or the reactor vessel through valve LP-24, and discharge to the SFP. The remaining cooling trains operate as for normal cooling.

Drains are located in the deep end of the fuel transfer canal. A six inch drain line, with double isolation valves, connects the fuel transfer canal to the reactor vessel cavity. Two four inch drain lines connect into a common four inch line that drains the fuel transfer canal to the reactor building normal sump. The common portion of the four inch drain line has two isolation valves that are open during normal operation and are closed during refueling prior to filling the fuel transfer canal. Potential break locations, which could result in a loss of fuel transfer

canal inventory during refueling, are seismically designed to Duke Class C piping standards.

Those portions of the SFCS which are used during normal or emergency operation are designed to Duke Class C piping standards. These design standards ensure that no pipe break should occur, as a result of a seismic event, which could result in a loss of SFP inventory. Level indicators are provided to alarm on low or high water level in the SFP. Penetrations of the pool liner, with the exception of the transfer tubes, are arranged to prevent accidental drainage of the pool. In addition, temperature sensors and flow monitors in the SFCS alarm on high temperature or loss of flow.

Following the original licensing of the plant, the SSF was added as a backup to existing systems to provide an alternate and independent means to achieve and maintain hot shutdown conditions at Oconee following a fire, turbine building flood, or security event. The SSF was approved by the staff in an SER dated April 28, 1983. The SSF is capable of maintaining all three units at hot shutdown conditions for 72 hours. The SSF is also considered the alternate ac power source for station blackout and provides a diverse means of mitigating a tornado.

Part of the SSF design consists of the SSF Reactor Coolant Makeup (RCMU) System. This system provides cooling to the reactor coolant pump seals and makes up for normal RCS leakage, including seal leakage, that cannot be isolated during an SSF event. Each Oconee unit has a RCMU pump, with a maximum flow rate of 29 gpm, in the basement of its reactor building. The suction source for each RCMU pump is the SFP via a connection in the transfer tubes. Alternate letdown from the RCS is also directed back to the transfer tubes. In order to assure timely manning of the SSF, the valves which isolate the transfer tubes from the SFP (SF-1 and SF-2) are normally open. This lineup ensures that adequate suction inventory remains available to the RCMU pumps. Design calculations indicate that the water level in the SFP will still be at least one foot above the top of the fuel assemblies following the 72 hour SSF mission time. However, actions to make up to the SFP should be initiated well before the SFP level decreases to one foot above the fuel.

The RCMU System is designed per the requirements stated in ASME Section III Class 2 (1974 Edition, Summer 1975 Addendum), and to Oconee Class B. This system is designed to withstand the Operating Basis Earthquake (OBE) and Safe Shutdown Earthquake (SSE).

3.0 Administrative Controls

Administrative controls are in place to ensure that the SFP and its interfacing systems are operated in a manner to minimize the potential for inadvertent draining of the SFP. Each day, operator rounds monitor the SFP liner plates for potential leakage. The operator verifies that the SFP leak detection valves are open and that no leakage is present. These inspections are documented in an enclosure to procedures OP/1/A/1102/20 and OP/3/A/1102/20 for the Units 1 and 2 SFP and Unit 3 SFP, respectively.

The administrative controls in place to reduce the likelihood of potential SFP drain down scenarios are as follows:

During refueling operations, the fuel transfer canal (FTC) blank flanges are removed and the FTC drain lines are isolated using procedure OP/1,2,3/A/1102/15, Filling and Draining Fuel Transfer Canal. This procedure directs the closure and red tagging of SF-1 and SF-2 and the draining of both transfer tubes prior to removal of the flanges. These procedural steps isolate the SFP from the transfer tubes and ensure that there is no leakage past SF-1 and SF-2 after they are closed. Maintenance procedure MP/0/A/1405/001, Fuel Transfer Tube Cover Plate - Installation and Removal, is used to remove and install the cover plates. The procedure has prerequisites with sign-offs to verify with Operations that the transfer tube isolation valves are closed, drained, and red tagged prior to starting work. The procedure gives a specific sequence for loosening and removing bolts, leaving four equally spaced pairs of bolts in place until the flange cover is cracked off its seating surface. After the remaining standing water is drained, the final bolts are removed. SF-1 and SF-2 are not reopened until the FTC is filled to normal refueling level and the red tags are cleared as directed by procedure OP/1,2,3/A/1102/15.

The opening of SF-1 or SF-2 prior to reaching refueling level in the FTC would be in violation of procedural requirements used to fill the FTC. If these valves were prematurely opened, decreasing level in the SFP would be observed by the operator opening the valve and would be indicated to the control room operators by the control room level meter and a low SFP level statalarm. A Limit and Precaution in procedure OP/1,2,3/A/1102/15 requires local monitoring of SFP level any time alignments are being made with inoperable SFP level instruments or alarms. Additionally, a reduction in SFP level would be indicated by an alarm on RIA-6 (SFP area monitor).

While in the refueling mode, SF-1 and SF-2 are open and the SFCS draws suction from the FTC and discharges to the SFP. In this configuration, a misalignment and diversion of the SFCS, which results in continued suction from the FTC with discharge to the SFP isolated, would be recognized by a decrease in SFP level and a low level alarm in the control room. In addition, the diverted flow would cause an observable increase in levels in other systems. A loss of FTC inventory would prompt the use of procedure AP/1,2,3/A/1700/26, Loss of Decay Heat Removal. This procedure directs the operators to close SF-1 and SF-2, thus isolating the SFP from the FTC and the transfer tubes.

During an emergency requiring activation of the SSF, the SSF RCMU pump provides reactor coolant pump seal cooling and system makeup. The RCMU pump takes suction from the SFP via the fuel transfer tubes with SF-1 and SF-2 open and the blank flanges installed. Procedure AP/0/A/1700/25, SSF Operating Procedure, directs the SSF operators to request that the Technical Support Center (TSC) monitor SFP level. This procedure also directs the operators to request that the TSC initiate makeup to the SFP as soon as possible. If none of the normal makeup sources are available, remote makeup capability exists by using fire trucks to pump lake water into the SFP.

Leakage from the RCMU System during normal operation of the Oconee units would be contained within the reactor building and would be indicated by an increase in reactor building normal sump level. This indication, along with low SFP level and RIA alarms, would alert the control room operators

that SFP level is decreasing. The alarm response guidelines direct the operators to suspend all fuel handling operations, check valve alignments, and initiate makeup to the SFP via procedure OP/1,2,3/A/1104/06, Spent Fuel Cooling System.

Periodic performance tests of the RCMU pump are performed where the pump draws suction from one transfer tube and discharges to the other transfer tube. The control room is notified prior to performance of this test and would have the same control room indications described above if SFP inventory were inadvertently lost during the test.

3.1 Procedure Enhancements

In performing the evaluation of sequences associated with accidental draining of the SFP, opportunities for procedure enhancements were investigated to improve the ability of the operators to respond to loss of SFP inventory events. The following briefly describes the procedure enhancements identified from this investigation.

- When preparing to remove the fuel transfer tube flange, the refueling canal drains are normally closed and the deep end of the canal is filled with up to a foot of water to reduce radiation exposure to the flange removal crew. This helps to reduce the potential for a loss of SFP level as the result of improper flange removal sequence. Even if the flange were removed out of sequence, if the drains are closed, the levels in the SFP and fuel transfer canal would equalize and the fuel would remain covered with water. The explicit requirement to close the drains and fill the deep end of the fuel transfer canal to the one foot level prior to flange removal, will be added to OP/1,2,3/A/1102/15.

- The maintenance procedure used to remove the flange (MP/0/A/1405/001) will be changed to require verification that water is standing in the deep end, the fuel transfer canal drain lines are closed, and SF-1 and SF-2 are verified to be closed with a remote camera, prior to flange removal.

- For SFP drain down sequences involving the SSF piping that occur during normal operation, procedures do not currently direct the operators to attempt to isolate the leak by closing SF-1 and SF-2. These steps will be added to the procedures.

4.0 Backfit Modifications

Duke's engineering staff identified three potential modifications to the SFP that would further reduce the possibility of inadvertently draining the pool. A brief description of each of these modifications is provided below. Given the limited time available to assess these modifications, the cost estimates are considered to be rough approximations. In addition, none of these modifications have been evaluated for constructability. Further analysis would be necessary to confirm the feasibility of these modifications.

4.1 Standpipe Modification

One possible modification is to install vertical pipes from the top of the fuel transfer tubes (approximate elevation of 811'3") inside the SFP to a level about one foot above the fuel racks (approximate elevation of 817'6"). These lines would have isolation valves to permit removal of the transfer tube blank flange for refueling. These isolation valves would be equipped with manual operators and reach rods to permit local operation from the SFP deck similar to current operation of SF-1 and SF-2. The standpipe modification would allow the units to operate with SF-1 and SF-2 normally closed. The new isolation valves would remain open for normal operation to ensure a flow path for the SSF RCMU pumps. This modification effectively eliminates the risk of inadvertently draining the pool below the fuel while the SSF is in service. It also protects against a failure of the transfer tube and connected piping (drains and SSF piping) exterior to the SFP, as well as inadvertent draining through misalignment of these paths.

However, since this protection is present only when SF-1 and SF-2 are closed, leakage paths, seal plate failure, and FTC drain scenarios are not eliminated during refueling when SF-

1 and SF-2 are open. Material costs include six inch stainless steel pipe, lateral structural supports, six six-inch isolation valves, and remote valve operators (reach rods). Labor costs include engineering design, fuel movement support, craft support, planning and scheduling, and contract labor for divers and welding equipment. The cost of implementing this modification is approximately $650,000 for the Units 1 and 2 SFP and $450,000 for the Unit 3 SFP (1998 dollars).

4.2 SF-1 and SF-2 Modification

This potential modification involves replacing the hand wheels on transfer tube isolation valves SF-1 and SF-2 with electric motor operators. This modification would allow operation with SF-1 and SF-2 normally closed. Operator action would be credited during SSF activation to open SF-1 and SF-2 to align the SFP inventory to the RCMU System. The operators would require safety-related power supplies and would be operated from the SSF. Insufficient time was available to assess motor sizing and the availability of power. The design would require suitable structural supports for seismic loadings.

This design protects against failure of the SSF piping, transfer tube drain lines, and the blank flange during normal operation. However, during refueling or operation of the SSF RCMU System, valves SF-1 and SF-2 will be open. Thus, during periods where SF-1 or SF-2 are open, this option offers no additional drain down protection beyond the features associated with the current design and administrative controls. In addition, this modification has the undesirable effect of introducing an additional failure mode for the SSF and increasing the time required by the operator to actuate the SSF. Thus, adding motor operators such that SF-1 and SF-2 could be closed during normal operation would decrease the reliability of the SSF. The SFP risk analysis for this potential modification does not consider the adverse impact on SSF reliability.

Material costs include six electric motor operators, lateral structural supports, cables, breakers, switches and controls for the SSF and Oconee control rooms. Labor costs include engineering design, fuel movement support, craft support, and planning and scheduling. The cost of implementing this

modification is approximately $950,000 for the Units 1 and 2 SFP and $700,000 for the Unit 3 SFP (1998 dollars).

4.3 Weir Wall Modification

This potential modification involves the construction of two interior walls extending the entire length of the SFP. The walls would be constructed of stainless steel plate welded to the pool liner at a distance of 4.5 feet from each side. The walls would extend from the SFP floor to an elevation of approximately 817.5 feet, which would provide a minimum water level of approximately one foot above the top of the fuel. The weir walls would divide the SFP into three regions. One region would contain the storage racks and fuel assemblies. The other two regions, on each side of the storage racks, would contain the transfer tubes, carriages, and fuel movement equipment.

The weir walls would prevent fuel uncovery caused by failures of the transfer tubes and piping attached to the transfer tubes. It should be recognized that the weir walls will not eliminate the possibility of uncovering spent fuel. Following a postulated drain down scenario, boil off of the remaining SFP inventory will eventually uncover the assemblies. Thus, the weir walls would simply increase the time available to the operators to initiate makeup to the SFPs.

Material costs include 0.25 inch stainless steel plate approximately 58 feet long by 9 feet high plus 26 feet long by 15 feet high on both sides of each SFP along with necessary structural supports. Labor costs include engineering design, fuel movement support, craft support, planning and scheduling, and contract labor for divers and welding equipment and personnel exposure. The cost of implementing this modification is approximately $1,200,000 for the Units 1 and 2 SFP and $1,000,000 for the Unit 3 SFP(1998 dollars).

5.0 <u>Public Risk Analysis</u>

Backfit analyses require a value/impact analysis to show that the proposed changes to the plant will result in safety improvements commensurate with the cost of implementing the change. The value (or safety improvement), is generally

expressed in terms of public health cost averted and is derived from the value of $2,000 per person-rem, combined with the cost of offsite property damage.

This section of the report summarizes analyses conducted by Duke to determine the public health risk and cost associated with concerns associated with the Oconee fuel transfer tube.

5.1 Method

Although accidents postulated to result in uncovering spent fuel are not normally modeled by PRA analyses, the NRC has sponsored several studies related to spent fuel pool accidents beyond the design basis. These include;

- NUREG/CR-4982, "Severe Accidents in Spent Fuel Pools in Support of Generic Safety Issue 82," June, 1987
- NUREG/CR-5281, "Value/Impact Analyses of Accident Preventive and Mitigate Options for Spent Fuel Pools," March, 1989
- NUREG-1353, Regulatory Analysis for the Resolution of Generic Issue 82, "Beyond Design Basis Accidents in Spent Fuel Pools," April, 1989

Duke has relied heavily on the above NUREGs in this evaluation of the potential risk associated with the Oconee SFP. Where possible, standard probabilistic risk assessment methods were used to determine the public health risk for sequences that are affected by the SFP and the fuel transfer tube. This involved:

- determining the potential sequences that could result in fuel uncovery,
- estimating the frequency of initiating events,
- determining the probability that attempts to mitigate the event will fail for each scenario,
- determining the consequences to the public as a result of fission product release.

To determine the value of proposed backfits, the safety improvement was also determined assuming the proposed changes are made. Then the value (or safety improvement), was expressed in terms of averted cost to the public. The averted cost includes public health cost ($2,000 per person-rem) as well as the cost of offsite property damage.

5.2 Scenarios of Concern

The ONS SFPs and fuel transfer tubes are configured such that there is the potential for the SFP coolant to be drained to approximately six feet below the top of the fuel assemblies. A review of past operational experience was conducted using Duke's Operational Experience Database (OEDB) to help determine potential scenarios and their likelihood. The OEDB contains information on industry experience from sources such as INPO reports, NRC Information Notices, Generic Letters, etc. and other sources (vendor reports, etc.). Table 1 contains a list of industry events that were determined to be related to the ONS SFP issues. From these past events, as well as a review of the ONS design and administrative controls, the following scenarios were identified that could result in uncovering the spent fuel at Oconee.

- If normal reactor coolant pump seal cooling is lost, the SSF RCMU pump will be used to provide seal cooling. The suction source for the RCMU pump is the SFP via the fuel transfer tube. Procedures direct the operators to provide makeup to prevent excessive loss of the SFP inventory when the RCMU System is in operation. For this sequence to result in fuel uncovery, the SSF RCMU System must be in operation for several days with a failure to provide makeup to the SFP.

- The fuel transfer tubes are constructed with a bellows seal arrangement on both ends. If a heavy object is dropped on and ruptures the pool liner, transfer tube, or transfer tube bellows, then SFP water could be lost to either the reactor building or the auxiliary building.

  Heavy loads handled in or over the fuel transfer canal consist of the missile shields, reactor vessel head (and associated maintenance tooling), plenum assembly, core

support assembly and internals indexing fixture. However, any time that these heavy loads are handled in containment, SF-1 and SF-2 are already isolated and the canal deep end is filled. Therefore, even in the unlikely event that one of these loads were dropped and managed to damage the bellows or transfer tube, the SFP inventory would not be lost. A damaged transfer tube inside the deep end of the transfer canal has no leak path from the pool with SF-1 and SF-2 closed. A damaged bellows in the transfer canal may provide a leak path from the canal to the reactor building sump, but again does not provide a leak path from the SFP due to the closed isolation valves in the pool. The potential scenario of damage to transfer tubes and/or bellows on the refueling canal side can be screened out due to the absence of a leak path during exposure to a heavy load drop.

The primary heavy load on the SFP side of the transfer tube would be the spent fuel shipping cask. The cask drop accident has been previously analyzed by Duke. The analysis concludes that a direct impact to the SFP floor could result in a breach of the SFP liner, but that the concrete beneath the SFP floor would suffer minimal damage. The leakage resulting from such a drop is estimated to less than 24 gallons per day. Therefore, there is ample time to provide makeup to the SFP and/or make repairs to terminate the leakage prior to uncovering fuel.

Should the cask impact the transfer tube, isolation valve, or expansion joint, it is conceivable that they could be sufficiently damaged to create a leak path. The transfer tube rupture inside the pool does not reduce SFP level, as this is equivalent to having SF-1 and SF-2 open, which is the normal practice. Fluid is contained at the reactor building end of the tube by blank flanges and isolation valves. The SFP wall leak is bounded by existing analyses since it could not take a direct blow from a dropped cask. Therefore, the only damage of concern would be the breach of the expansion joint at the pool wall. Such a breach would leak water into the annular space between the transfer tube and the sleeve which joins the auxiliary building and reactor building.

This path is contained by double-pipe seal welds at the reactor building liner plate, however, and is of no consequence. During this study, Duke was unable to conclusively determine whether a seal weld exists between the sleeve and the pool liner behind the expansion joint. It is believed, however, that the bond between the concrete and this sleeve would be sufficient to eliminate, or reduce to negligible values, any potential leakage around the outside of the sleeve. This assumption is reasonable considering the relatively small perimeter of the sleeve as compared to the leak paths previously analyzed by Duke and similar wall thicknesses around the SFP. Therefore, the potential scenario of damage to the transfer tube bellows in the SFP can be screened out due to the low potential for significant leakage.

- During refueling while taking SFP cooling suction from the refueling canal deep end, a pipe break, valve failure, or operator error could result in a flow diversion. For this sequence to result in uncovering the fuel, there would also have to be a failure to terminate the flow diversion, a failure to make up to the SFP and a failure to isolate the transfer tubes with gate valves SF-1 and SF-2.

- During refueling with the fuel transfer tube open, a piping or valve failure on the deep end drain lines would result in draining the contents of both the fuel transfer canal and the SFP to the containment sump. This type of sequence could also occur as the result of improper removal of the transfer tube blind flange. For this sequence to result in uncovering the fuel, there would also have to be a failure to make up to the SFP and a failure to close the transfer tube gate valves.

- During normal operation, failure of a transfer tube or piping connected to it would result in a loss of SFP inventory. For this to result in uncovering the fuel, there would also have to be a failure to make up to the SFP and a failure to close the transfer tube gate valves (SF-1 and SF-2).

- During refueling with the fuel transfer canal filled and the fuel transfer tubes open, failures of the steam generator nozzle dams, failure of seals during RCP maintenance, failure of the reactor cavity seal, or LPI system LOCAs could cause loss of SFP level. For these type failures, both the fuel transfer canal and the SFP would drain down to a level just above the fuel. Additionally, the suction point of the spent fuel cooling system during refueling operations is in the deep end of the fuel transfer canal and would still be available. Therefore, sequences of the type described above would not result in fuel uncovery and would not cause a release of fission products to the public. Therefore, there was no further consideration of sequences of this type.

5.3 Analysis of Initiating Event Frequencies

The first step in determining the risk associated with the sequences of concern is to estimate the frequency of the initiating events. The following briefly describes the method used to estimate these sequence frequencies.

SSF Sequences- The Oconee SSF RCMU pump is used to provide reactor coolant pump seal cooling in the unlikely event that normal seal cooling is lost. The SSF is used in mitigating certain accidents, including station blackout, tornado, seismic events, external floods, turbine building floods, and turbine building fires. The Oconee PRA study is used to determine the likelihood the SSF would be called upon to mitigate these accidents. Table 2 lists the sequences and their associated frequencies from the Oconee PRA, Revision 2. The total frequency of this scenario from all potential initiating events is 1.2E-4 per year for each pool.

Flow Diversion Scenario - This scenario consists of events that occur while the "B" Train SFP Cooling is aligned to the FTC deep end with SF-1 and SF-2 open. This diversion is assumed to either pump or siphon coolant from the FTC to some other location than the SFP. It is potentially caused by either a pipe break, valve failure, or human error. The probability of a pipe break was estimated to be roughly 3.6E-6 using the methodology found in EPRI Report TR-102266 "Pipe Failure Study Update". A 10 day window was used for the length of exposure to this failure mode. Based on the

actual events that have occurred over the past 10 years, the probability of a diversion due to valve failure or human error is estimated at roughly 2E-4 per outage. This estimate only considers those events judged to have the potential for fuel uncovery. Assuming an 18 month fuel cycle, the Units 1 and 2 pool will be exposed to 1.3 outages per year, which would result in a frequency of a loss of SFP inventory through a flow diversion of 2.6E-4 per year. For the Unit 3 pool, which would be exposed to 0.67 outages per year, the resulting frequency of a loss of SFP inventory from a flow diversion would be approximately 1.3E-4 per year.

Coolant Loss through FTC Deep End Drains - The cause of this event can be due either to a pipe break on the drain lines during refueling operations or due to improper removal of the blind flange on the fuel transfer tube (human error). The potential for a valve transfer was not considered due to a second isolation valve located downstream. The probability of a line break was estimated to be 1.4E-07 using the methodology found in EPRI Report TR-102266. A 10 day window was used for the length of exposure to this failure mode. Improper removal of the blind flange is actually a series of human errors involving failure to close SF-1 and SF-2, failure to verify proper draining of the transfer tube, and failure to close the deep end drains prior to flange removal. If the drains are closed, the levels in the SFP and Refueling canal would equalize and the fuel would remain covered with water. With the procedure enhancements described in section 3.1, the probability of this sequence of human errors is estimated to be 1.7E-7. Thus the total probability of losing coolant through the deep end drains is approximately 3.1E-7 per outage. Assuming an 18 month fuel cycle, the Units 1 and 2 pool will be exposed to 1.3 outages per year, which would result in a frequency of a loss of SFP inventory through the refueling canal drains of 4E-7 per year. For the Unit 3 pool, which would be exposed to 0.67 outages per year, the resulting frequency of a loss of SFP inventory through the refueling canal drains is approximately 2E-7 per year.

Transfer Tube Leak - The potential for losing coolant from a transfer tube is dominated by the probability of failure of the piping connected to the tubes. The connecting pipes in this case are the SSF RCMU pump suction piping, SSF RC

letdown piping, and the transfer tube drain lines (1 per tube). In each of these lines, an isolation valve is located downstream from the tube connection and is normally closed. The tube drains are both one-half inch lines and are not considered large enough to cause fuel uncovery prior to isolation of SF-1 and SF-2 or establishing adequate pool makeup. For the remaining SSF piping, the probability of a line break has been estimated using the methodology from EPRI TR-102266. For this methodology, this 3 inch piping was classified as PWR safety injection piping (Group Size #2) which has a failure rate of 1.13E-10 per section-hour.

The piping sections of interest are those segments located between the Transfer Tube and the first isolation valve (which is normally closed). A correction factor 0.38 was applied for piping failure modes that are not applicable to these specific pipe segments. (See Chapter 6 of EPRI TR-102266 for an example of applying this factor.) An exposure time of 8760 hours was used for this estimate. For the Unit 3 SFP the combined mean failure probability of the SSF suction and letdown piping is estimated at 7.5E-07 per year. For the Units 1 and 2 SFP, there are two pairs of transfer tubes; and therefore, the probability of SSF pipe failure is doubled or 1.5E-06.

5.4 Analysis of Sequence Mitigation Probabilities

The next step in quantifying the risk associated with spent fuel accident sequences involves estimating the likelihood that attempts to mitigate the accident prior to fuel uncovery would fail. The following briefly describes the mitigating actions and the estimated likelihood that these actions would fail.

SSF Sequences- Initiating events such as station blackout, turbine building flooding or fire, external flooding, tornado, or seismic events would require the SSF RCMU pump to take suction from the SFP via the fuel transfer tube. The mitigating action for all these sequences would be to supply makeup to the SFP prior to the fuel being uncovered. There would be over 74 hours from the time the SSF is initiated until the fuel in the SFP would be uncovered. Actions to provide makeup could be accomplished either

through the normal SFP makeup path or from a fire truck if power is unavailable. Both these actions are covered in procedures and Oconee operators are familiar with the actions required. Modifications have recently been made that would facilitate the use of the fire truck to refill the SFP. Using methods consistent with those in the Oconee PRA, the estimated probability for failure to provide makeup to the SFP is 0.05. Since over three days would be available prior to fuel uncovery, and since the TSC, OSC, and EOF would all be available to assist in recovery actions, the following reduction factors were also applied for the SSF scenario:

For external initiated events-	0.1
For internal initiated events -	0.05

This results in the following probabilities for failure to provide SFP makeup or recover other means to mitigate an SSF event;

External Flood -	5.0E-3
Turbine Building Flood -	2.5E-3
Seismic Event -	5.0E-3
Tornado -	5.0E-3
Turbine Building Fire -	5.0E-3
Station Blackout -	2.5E-3

Flow Diversion Scenario - While in the refueling mode, SF-1 and SF-2 are open and the SFCS draws suction from the FTC and discharges to the SFP. In this configuration, a misalignment of the SFCS, valve failure, or piping failure, could result in continued suction from the FTC with discharge to some other location. This situation would be recognized by a decrease in SFP level and low level alarms in the control room. In addition, the diverted flow would cause an observable increase in levels in other systems or sumps. A loss of FTC inventory would prompt the use of procedure AP/1,2,3/A/1700/26, Loss of Decay Heat Removal. This procedure directs the operators to trip the operating SFP cooling pump, to close the isolation valves and to close SF-1 and SF-2. Assuming a leakage rate of 1000 gpm for this scenario, approximately 9 hours would be available to take action prior to fuel uncovery.

Using methods consistent with the Oconee PRA, this action would be considered a simple action outside the Control Room and would be assigned a probability of failure of 0.01. Additionally, review of the actual events would indicate that it would be likely that the operators could terminate the flow diversion by other means such as isolating the leakage path. Because of this, and the long time available in this sequence, an additional factor of 0.1 was applied. Therefore, a probability of 0.001 was used for failure to terminate a flow diversion event prior to the fuel being uncovered.

Coolant Loss through FTC Deep End Drains - The cause of this event can be due either to a pipe break on the drain lines during refueling operations or due to improper removal of the blind flange on a fuel transfer tube (human error). This situation would be recognized by a decrease in SFP level and low level alarms in the control room. A loss of FTC inventory would prompt the use of procedure AP/1,2,3/A/1700/26, Loss of Decay Heat Removal. Currently, this procedure directs the operators to close SF-1 and SF-2, and isolate the transfer tube from the SFP. Depending on which pipe is assumed to fail, from 4 to 10 hours would be available to take action prior to fuel uncovery.

Assuming these actions are proceduralized and using methods consistent with the Oconee PRA, these actions would be considered simple actions outside the Control Room and would be assigned a probability of failure of 0.01.

In addition to the ability to terminate the SFP leakage, there are several ways to provide makeup to the SFP. These include the methods normally used to provide pool makeup, the ability to provide makeup from the BWST, and remote makeup capability from an external makeup line to an external water source (fire trucks, lake water, etc.). Providing makeup to the SFP would provide additional time to isolate the leakage path. No explicit credit was taken for these options of providing makeup to the SFP. However, they provide additional confidence in the ability of plant personnel to mitigate a SFP leakage accident.

Transfer Tube Leak - The potential for losing coolant from a transfer tube is dominated by the probability of failure of

the piping connected to the tubes. This situation would be recognized by a decrease in SFP level and low level alarms in the control room. Between 8 to 12 hours would be available to take action prior to fuel uncovery. Currently, procedures direct the operators to make up to the SFP using one of numerous normal makeup paths. Additionally, steps will be added to direct the operators to close SF-1 and SF-2 to isolate the leak.

Assuming these actions are proceduralized and using methods consistent with the Oconee PRA, these actions would be considered simple actions outside the Control Room and would be assigned a probability of failure of 0.01.

In addition to the ability to terminate the SFP leakage, there are several ways to provide makeup to the SFP. These include the methods normally used to provide pool makeup, the ability to provide makeup from the BWST, and remote makeup capability from an external makeup line to an external water source (fire trucks, lake water, etc.). Providing makeup to the SFP would provide additional time to isolate the leakage path. No explicit credit was taken for these options of providing makeup to the SFP. However, they provide additional confidence in the ability of plant personnel to mitigate a SFP leakage accident.

5.5 Analysis of Sequence Frequency With Potential Pool Modification

Tables 4a and 4b show the combination of initiating event frequencies and failure to mitigate probabilities to obtain sequence frequencies for all the initiating events. As can be seen from these tables, the frequency of a SFP accident that results in fuel uncovery is approximately 8.4E-7 per year for the Units 1 and 2 SFP and 7E-7 per year for the Unit 3 SFP.

To perform a value/impact assessment, the value of potential safety improvements associated with proposed plant changes must be evaluated. The value, or safety improvement, can either be in the form of a reduction in the likelihood of the initiating event or an improvement in the ability to mitigate an event. Oconee engineering has identified one potential modification that would reduce the likelihood of an event occurring and two modifications that could help to

mitigate an event if it were to occur. The following briefly describes the assessment of the risk improvement each modification could achieve.

5.5.1 Improved Initiation Modification

This potential modification involves replacing the hand wheels on transfer tube isolation valves SF-1 and SF-2 with electric motor operators. This modification would allow operation with SF-1 and SF-2 normally closed. Operator action would be necessary during SSF activation to open SF-1 and SF-2 to align the SFP inventory to the RCMU System. The electric motor operators would require safety-related power supplies and would be operated from the SSF.

This modification protects against failure of the SSF piping, transfer tube drain lines, and the blank flange during normal operation. However, during refueling or operation of the SSF RCMU System, valves SF-1 and SF-2 will be open. Thus, during periods where SF-1 or SF-2 are open, this option offers no additional drain down protection beyond the features associated with the current design and administrative controls.

The risk improvement associated with this modification would be to eliminate the potential transfer tube leak caused by SSF piping failure while the plant is at power. However, this modification would not prevent a drain down event caused by the SSF while the transfer tube is open during refueling. The risk reduction of the modification is assumed to be approximately a factor of ten. As can be seen from Tables 5a and 5b, this modification would decrease the frequency of a SFP accident by 1.4E-8 per year for the Units 1 and 2 pool and by 6.8E-9 per year for the Unit 3 pool. However, this modification would leave the majority of the SFP draining risk unaffected. Also, this modification would adversely impact the reliability of the SSF and the ability of the operators to activate the system within the necessary time. This adverse impact on the SSF has not yet been quantified.

5.5.2 Improved Mitigation Modifications

Oconee Engineering has identified two potential modifications to the ONS SFP that could prevent draining of the SFP below the top of the spent fuel assemblies. These modifications would improve the ability to mitigate an event rather than prevent the event from occurring. The first modification would be to add a standpipe to the fuel transfer tube so the SSF RCMU System suction point would be one foot above the fuel in the SFP. This modification would only be effective in mitigation of the SSF sequences and the transfer tube leak caused by a SSF pipe break. The second proposed modification would be to add a weir wall to the pool that would retain the water level above the fuel. The weir wall would be effective for all the scenarios identified in this analysis. This would make the Oconee SFP similar to many PWR pools in that it would have a physical barrier to prevent draining of the SFP below the top of the spent fuel assemblies.

However, neither of the proposed modifications would eliminate all risk associated with the sequences of concern. Since all sequences identified would result in loss of SFP cooling, a weir wall or standpipe would only provide additional time to recover from the initiating event. Without makeup, heatup and boil off of the remaining water would result in fuel uncovery and eventual fission product releases identical to the draining sequences. Since the potential "value" in a value/impact analysis is public risk "benefit" if the modifications are made, the risk "benefit" would be equal to the current risk minus the remaining risk.

The following describes the potential risk benefit of each modification for each scenario.

5.5.2.1 Standpipe Modification

The standpipe would be attached to the transfer tube and extend to one foot above the fuel assemblies. With this configuration, SF-1 and SF-2 can be closed during normal operation.

SSF Scenario - With the standpipe in place and SF-1 and SF-2 closed during normal operation, the SSF will only be able to take suction until the water level in the SFP is one foot

above the top of the fuel, rather than being able to take suction until the fuel is uncovered. As described above, this potential modification would not completely eliminate the risk of fuel uncovery. Even if the standpipe limits the SFP level decrease, it cannot prevent the eventual boil off of the remaining water. The effect of the standpipe is to provide additional time for mitigation, and the improvement in risk is related to the improvement in the human error probability for failure to mitigate the event.

In the SSF scenarios, the mitigation failure is a failure to make up to the SFP or a failure to recover normal seal cooling. Without the standpipe modification it would take nearly 74 hours for the SSF to cause fuel uncovery. Since normal cooling is lost, the water in the SFP would be at the point of boiling by the time the level reached the standpipe. Therefore, the additional time provided in the SSF sequences would only be the approximately two hours required to boil away the one foot of water remaining over the fuel. If actions to make up to the SFP have not been successful for 74 hours, it is unclear how a few additional hours would help improve the reliability of mitigative actions.

The normal methods for quantifying human error probabilities for actions that are not time critical will result in the same probability value regardless of the available time. In reality, if actions are not successful in several hours, it is unlikely that providing several more hours would result in a significant improvement in the probability of success. However, since normal methods for human error calculations are not adequate to determine the potential improvements in human error probability for the SSF scenario, a conservative approach is to assume the improvement is proportional to the increase in time available. Assuming 74 hours to uncover the fuel without the standpipe, and 76 hours if the standpipe is installed, results in an improvement of a factor of 1.03. As can be seen from Tables 6a and 6b, this would reduce the frequency of a SFP accident caused by an SSF scenario by only 1.63E-8 per year for both the Units 1 and 2 SFP and the Unit 3 SFP.

Flow Diversion and Failure of the Deep End Drains - For these scenarios, the plant must be in a refueling mode with SF-1 and SF-2 open. As a result, the addition of the

standpipe would not reduce the risk of these sequences. As shown in Tables 6a and 6 b, the reduction factor would be 1.0, or no change in risk.

Transfer Tube Leak Caused by SSF Pipe Break - For this scenario, the potential impact of the standpipe would be significant. Without the standpipe, the operators would have to close SF-1 and SF-2 within a period of 8 to 10 hours. If the standpipe was in place with SF-1 and SF-2 closed, the drain down would be limited to one foot above the top of the fuel. The standpipe would not only extend the time available for the operators to respond, it also allows them to simply make up at the boil off rate using the normal makeup paths.

However, this would only be a benefit while SF-1 and SF-2 are closed. If they are open, as they would be during an outage, the standpipe would not provide any risk reduction. An overall risk reduction of approximately a factor of ten is assumed for the SSF pipe break sequences. As can be seen from Tables 6a and 6b, this would be a reduction of 1.4E-8 for the Units 1 and 2 pool and 6.8E-9 for the Unit 3 pool.

5.5.2.2 Weir Wall Modification

As described earlier, weir walls could be added to the SFPs that would retain the water level above the fuel. This would make the Oconee SFP similar to many PWR pools in that it would have a physical barrier to prevent draining of the SFP below the top of the spent fuel assemblies.

SSF Scenario - With the weir wall in place the SSF will only be able to take suction until the water level in the SFP is one foot above the top of the fuel, rather than being able to take suction until the fuel is uncovered. As described above, this would not completely eliminate the risk of fuel uncovery. Even if the weir wall prevents draw down of the pool, it can not prevent the eventual boil off of the remaining water. The effect of the weir wall is to provide additional time for mitigation, and the improvement in risk is related to the improvement in the human error probability for failure to mitigate the event. In the SSF scenarios, the mitigation failure is a failure to make up to the SFP or a failure to recover normal seal cooling. Without the weir

wall modification it would take nearly 74 hours for the SSF to cause fuel uncovery. Since normal cooling is lost, the water in the SFP would be at the point of boiling by the time the level reached the top of the weir wall. Therefore, the additional time provided in the SSF sequences would only be the time required to boil away the one foot of water remaining over the fuel, approximately two hours. If actions to make up to the SFP have not been successful for 74 hours, it is unclear how a few additional hours would help improve the reliability of mitigative actions.

The normal methods for quantifying human error probabilities for actions that are not time critical will result in the same probability value regardless of the available time. In reality, if actions are not successful in several hours, it is unlikely that providing several more hours would result in a significant improvement in the probability of success. However, since normal methods for human error calculations are not adequate to determine the potential improvements in human error probability for the SSF scenario, a conservative approach is to assume the improvement is proportional to the increase in time available. Assuming 74 hours to uncover the fuel without the weir wall, and 76 hours if the weir wall is installed, results in an improvement of a factor of 1.03. As can be seen from Tables 7a and 7b, this would reduce the frequency of a SFP accident caused by an SSF scenario by only 1.63E-8 per year for both the Units 1 and 2 SFP and the Unit 3 SFP.

Flow Diversion Scenario - The potential safety improvement for this sequence is more apparent. The weir wall would not only provide additional time for the operators to respond to terminate the flow diversion, it would also give them the option of simply providing makeup at a rate to keep the fuel covered. This could be accomplished with the normal makeup system. However, since the mitigative actions for this sequence are already very reliable, even without the weir wall modification, an additional factor of 10 was considered a reasonable reduction factor. As can be seen in Table 7a and 7b, this would result in reducing the SFP accident frequency by 2.34E-7 for the Units 1 and 2 SFP and by 1.17E-7 for the Unit 3 SFP.

Deep End Drain Failure, and Transfer Tube Leak Caused by SSF Pipe Break Sequences - For these scenarios also, the potential impact of the weir wall would be more apparent. Without the weir wall, the operators would have to close SF-1 and SF-2 within a period of 8 to 10 hours. If the weir walls were in place, the drain down would be limited to one foot above the top of the fuel. The weir walls would not only extend the time available for the operators to respond, they would also allow them to simply make up at the rate of boil off using the normal makeup paths. For this analysis it has been assumed that the weir wall modification would result in a factor of 100 improvement in the ability to mitigate the deep end drain failure and SSF pipe break sequences. As can be seen from Tables 7a and 7b, the weir wall modification would reduce the frequency of a SFP accident from a deep end drain failure by 4.0E-9 for the Units 1 and 2 SFP and by 2.0E-9 for the Unit 3 SFP. It would also reduce the frequency of the SSF pipe sequence by 1.5E-8 for the Units 1 and 2 SFP and by 7.4E-9 for the Unit 3 SFP.

5.6 Analysis of Consequences of SFP Drain Down Accidents

A leak in the SFP, boil off of the SFP inventory, or a combination of the two can result in uncovery and eventual heat up of the fuel in the SFP. Events of this type were analyzed in detail in NUREG/CR-4982, "Severe Accidents in Spent Fuel Pools in Support of Generic Safety Issue 82". As the fuel heats up, some of the fuel will experience cladding failure and may even experience more extensive damage associated with rapid zircaloy oxidation (zircaloy "fire"), NUREG/CR-4982. A zircaloy fire can result in a large release of the long lived isotopes in the fuel. This section describes the analysis of the off-site radiological consequences associated with the SFP drain down scenarios.

The following steps were used to estimate the off-site consequences:

1. Determine the SFP fission product inventory. The fission product inventory was determined for the Oconee Units 1 and 2 SFP. The Units 1 and 2 SFP was chosen since it is the largest of Oconee's SFPs and contains more fuel assemblies. Also, the Units 1 and 2 SFP

experiences more frequent core off-loads for outages due to two units using the pool. The pool will contain more recently discharged fuel than the Unit 3 SFP.

The ORIGEN2 code was used to generate end of cycle (EOC) batch-average fission product inventories for 1st-burn, 2nd-burn, and 3rd-burn fuel batches. Total core inventories are obtained by adding together individual batch inventories. Batch-specific fission product inventories are calculated at selected times post-shutdown (i.e., from 72 hours to 12 years post-shutdown) by the ORIGEN-2 code.

The fission product inventory is based on the number of assemblies in the pool, the time after shutdown, the time since discharge, and the burnup of the assemblies. Table 8 contains information used in determining the SFP inventory. The SFP was assumed to contain a full core off-load for times less than 35 days after shutdown. Inventories for times from 10 to 200 days after shutdown were estimated.

2. Determine the amount of fission products released. The amount of fission products released will depend on the extent of damage to the fuel. If an assembly's decay heat is high enough, the oxidation of the zircaloy cladding will become self-sustaining. Based on NUREG/CR-4982, for high density racks, such as Oconee's, the zircaloy fire may propagate to older, lower power assemblies. The NUREG predicts that under some conditions, zircaloy fire propagation may occur in assemblies stored as long as two years. Cladding failure may occur in a portion of the assemblies that have been stored for greater than two years.

   Two different cases were considered for this analysis. The first case consists of a zircaloy fire in fuel assemblies less than two years old with a gap release in the remaining assemblies. The second case consists of a zircaloy fire throughout the pool. The release fractions for the zircaloy fire are taken from Table 4.2 of NUREG/CR-4982. For cladding failure, the release fractions are assumed to be the gap release fractions from NUREG-1465.

The amount of fission products released from the pool is determined from the product of the release fractions and the fission product inventories. The inventory released from the pool is contained in Tables 9 and 10. The release fractions used in the analysis are contained in Table 11.

3. Determine the fraction of inventory released to the environment. Once the fission products are released from the fuel, they must travel through the SFP building and possibly through the ventilation system prior to reaching the environment. For this analysis, no reduction in release fractions is assumed for travel through the buildings.

4. Determine off-site consequences. The CRAC2 computer code was used to estimate the impact of the fission products released. The Oconee CRAC2 model with Oconee specific population, meteorology, and evacuation schemes was used. The fission product release was assumed to occur two hours and six hours after the notification to evacuate (warning time) was given. This time difference did not significantly impact the results. The release duration was assumed to be 10 hours. The CRAC2 runs were made for various times after shutdown (from 10 days to 200 days). Only the 50 mile population was considered in the analysis consistent with the NUREG/CR-4982 analysis.

5. Sensitivity study. A sensitivity study was performed using the inventory in NUREG/CR-4982 Table 4.3 for 30 days and Table 4.4 for 90 days and the Oconee CRAC2 model.

The results of the CRAC2 runs are contained in Table 12.

The total cost of a SFP accident would be the combination of the public health cost and the cost of property damage. The NRC's Regulatory Analysis Guide requires the use of $2,000 per person-rem to convert public health consequences to dollars. For this analysis, it is assumed that the least impact of a SFP accident would result in damage to the last batch of fuel discharged, and the worst accident would result in damage to all the fuel in the pool. As described

above, the public health consequences for these two accidents are 6E6 person-rem for the low estimate and 9E6 for the high estimate. As can be seen in Table 13, the cost of the public health consequences would be $1.2E10 for the low estimate and $1.8E10 for the high estimate.

Normally Duke Power has not used the property damage models of the CRAC2 code. As a result, no Oconee site specific property damage cost could be determined for the SFP accidents. However, since the consequences of the accident and the fission product releases are very similar to those determined in NUREG-1353, the property damage costs for Oconee are assumed to be bounded by the range of $3.5E9 to $3E10 provided in NUREG-1353.

As Table 13 demonstrates, the total cost of a spent fuel accident which results in uncovery and damage to the fuel could range from a low estimate of $1.5E10 to a high estimate of $4.8E10.

5.7 Potential Public Cost Averted

The cost of averted risk associated with each proposed modification can be determined by multiplying the SFP accident frequency reduction by the conditional cost of the accident. Tables 14a through 16a show the averted cost for the Units 1 and 2 SFP for each proposed modification. Tables 14b through 16b show the averted cost for the Unit 3 SFP.

As required by the NRC's Regulatory Analysis Guide, a discount factor of 7% was used to determine the present worth cost over a 20 year period. If a 40 year period is assumed, the costs would increase by a factor of 1.23.

As can be seen from Tables 14a and 14b, adding electric motor operators to SF-1 and SF-2 would be worth somewhere between $1,000 and $7,000 per pool. From Tables 15a and 15b, adding the standpipe would result in an averted public cost of between $4,000 and $16,000 per pool. From Tables 16a and 16b, the weir wall modification would result in an averted public cost of between $24,000 and $140,000 per pool.

5.8 Uncertainty

The calculated risk results, probability values, and consequence results are estimates and, therefore, contain their inherent uncertainties.

For the probability estimates of the accident sequences, the main sources of uncertainty are, (1) the uncertainty in the initiating events, (2) uncertainty in the estimates of human error (latent and dynamic) probabilities, and (3) the uncertainty in the flow rate and damage potential which primarily affect the timing of the mitigative actions. The estimated values in each of these parameters are mostly best estimates, and in reality, the actual value is expected to fall within a range of probabilities.

In the consequence analysis portion also, there are a number of uncertainties. The manner in which fuel damage may occur as a result of uncovery and dry out and the magnitude of fission products released and the strength and duration of the release are highly uncertain. This analysis relied upon previous NRC sponsored studies to model the fuel damage and fission product release phenomena. The offsite consequence portion of the analysis dealing with the population characteristics, meteorological impact, emergency planning response, and the health effect and property contamination models also contain varying degrees of uncertainty.

Thus the risk results presented here should be viewed as estimates, neither optimistic nor pessimistic, and not a bounding result.

6.0 Conclusions

Duke Power has evaluated potential modifications to the SFP that would further reduce the probability of these drain down scenarios. The incremental safety benefit of implementing these modifications has been analyzed by performing a public risk analysis. Duke Power has attempted to perform the public risk analyses using methods comparable to those which we believe the staff will use. The results of the public risk analysis are as follows:

- The probability of an accident sequence due to the low fuel transfer tube elevation leading to sustained fuel uncovery in the Oconee SFP is estimated to be approximately 8.4E-7 per year for the Units 1 and 2 SFP, and 7E-7 per year for the Unit 3 SFP.

- This probability is much less than the estimated core damage sequences for the plant.

- The Oconee SFP drain down accident scenario probability is comparable to the beyond design basis accident probability for typical SFPs as estimated in NUREG/CR-4982.

- Considering the Oconee specific probabilities and site characteristics, the public health risk of drain down accidents is estimated to be between 4 and 8 person rem per year per pool.

- Using $2,000 per person-rem and accounting for offsite property damage, the present worth of the potential averted public risk for even the most effective modification is in the range of $24,000 to $140,000 over the remaining life of the plant.

In summary, Duke has performed an analysis of the public risk of potential accidents in the SFPs which could lead to a beyond design basis accident due to the pool drainage potential. This analysis was performed using PRA techniques and making use of assumptions similar to the NRC studies documented in NUREG/CR-4982, NUREG/CR-5281, and NUREG-1353. The results of the public risk analyses are that modifications in excess of $24,000 to $140,000 are not cost justified. Based on the low probability of SFP drainage accident sequences and the low averted public risk when compared to the costs of additional modifications to the SFPs, Duke Power concludes that additional modifications to the Oconee SFPs are not justified from a public risk perspective.

However, Duke's study did identify procedural changes that will further reduce the likelihood of human errors that could lead to such an event. In addition, procedural enhancements to mitigate loss of SFP inventory events were

identified. Duke intends to implement these procedural changes to minimize the risk associated with loss of SFP inventory events.

Table 1 - Operating Experience Review of Potential Spent Fuel Pool Draining Events

Event	Descriptions	Sequence Type
Haddam Neck, 8/21/84	With the refueling cavity flooded to 23 feet, the reactor vessel flange seal failed and the refueling cavity drained to flange level in 20 minutes.	RV flange seal leak
Susquehanna, 9/12/87	Approximately 11,000 gallons of water were inadvertently drained from the Unit 1 and 2 spent fuel pools through a mispositioned valve.	Mispositioned valve
River Bend, 9/20/87	Operators opened the Condensate Storage Tank (CST) valves but failed to close the SFP purification suction line valves. Also, the anti-siphon device was plugged. Operators were alerted to the problem by the SFP area radiation monitor and the water level increase in the CST.	Human error resulted in flow diversion of SFP cooling
Wolf Creek, 12/22/87	A valve in the Spent Fuel Pool (SFP) Cooling return line to the RWST was left open. SFP level indicator and low level alarm on SFP cooling system pump suction were both inoperable. Operators discovered problem when SFP pump tripped.	Human error resulted in flow diversion of SFP cooling
Surry, 5/17/88	The fuel transfer canal door pneumatic seal failed allowing SFP leakage. Operators repressurized seals after 25,800 gallons of water were lost from the refueling canal.	Fuel transfer canal door seal failure (Does not Apply to Oconee)
Turkey Point, 8/16/88	Approximately 3,200 gallons of water (100 gpm) were lost trough a leaking valve in the spent fuel cooling system.	Valve failure in SFP cooling system results in flow diversion.

Table 1 - Operating Experience Review of Potential Spent Fuel Pool Draining Events

Event	Descriptions	Sequence Type
Browns Ferry, 9/16/88	Level in the SFP dropped 3 inches in 30 minutes when a diffuser line check valve failed to close. Operators closed the isolation valves to terminate the leakage.	Valve failure in SFP cooling system results in flow diversion.
Palisades, 10/3/88	Approximately 5,000 gallons of water was lost from the SFP when a valve failed to close completely during realignment of the SFP cooling system. The pump isolation valves were closed to terminate the leakage.	Valve failure and human error resulted in SFP cooling system flow diversion.
Vandellos, 4/29/91	SFP gate pneumatic seal failed when power was lost to auxiliary service buses. This allowed SFP leakage.	SFP gate seal failure (does not apply to Oconee)
Beaver Valley, 5/30/91	Fuel transfer canal door pneumatic seal failed allowing SFP leakage. Leakage terminated when levels equalized between the SFP and the transfer canal. SFP level decreased approximately 20 inches.	Fuel transfer canal door seal failure (does not apply to Oconee)
Almaraz, 9/2/91	During SFP reracking, insulation breakdown on a power feeder cable to a cutting tool caused arcing which resulted in damage to the SFP liner. The leak rate was 4 gpm.	SFP liner failure due to cutting tool failure.
Wolf Creek, 9/23/91	The fuel transfer canal door pneumatic seal failed allowing SFP leakage. Operators repressurized seals after SFP level had dropped 44 inches.	Fuel transfer canal door seal failure (does not apply to Oconee)
Millstone, 7/6/92	Following a loss of power transient while the unit was shut down, operators inadvertently cross connected the SFP and RCS. Approximately 10,000 gallons of water drained from the SFP.	Human error resulted in flow diversion of SFP cooling.

Table 1 - Operating Experience Review of Potential Spent Fuel Pool Draining Events

Event	Descriptions	Sequence Type
Catawba, 2/9/93	The spent fuel transfer tube isolation valve failed to fully close and the operators failed to check for proper draining prior to attempting to open the transfer tube flange. With the flange partially opened, the flange o-ring blew out and allowed 6000 gallons of water to leak before the operators could isolate the transfer tube.	Transfer tube leak caused by human error.
Comanche Peak, 10/26/93	Containment cavity lift gate pneumatic seal failure resulted in 20,000 gallons of refueling water being lost to the refueling cavity. The SFP was not affected since the transfer tube was isolated.	Containment cavity lift gate seal failure (does not apply to Oconee)
Tricastin, 1/31/94	A 15 ft long screwdriver was dropped and punctured the SFP liner. Water level in the SFP dropped 4 inches during the event.	Object dropped in SFP resulted in liner leak
Hatch, 12/28/94	A three inch diameter gash was torn in the SFP liner when a 350 pound core shroud bolt was dropped from one foot above the pool water surface. A steel cable sling failed as the bolt was being removed from the pool for shipment offsite. Approximately 2,000 gallons of water were lost before the liner drain valve was closed which isolated the leak.	Object dropped in SFP resulted in liner leak
Catawba, 5/22/1996	Improper valve alignment of the SFP cooling system allowed siphon to develop which caused 5,500 gallons of water to be drained from the SFP. A vent valve was open that terminated the siphon and stopped the leak.	Human error resulted in SFP cooling system flow diversion

Table 2 - Potential Initiating Events for Loss of Spent Fuel Pool Level Analysis

Scenario Description	Initiator Description	Unit 1&2 Pool Initiator Freq. (per Yr	Unit 3 Pool Initiator Freq. (per Yr)
SSF RCMP Suction w/ Failure to Refill	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate an **External Flood**	1.20E-05	1.20E-05
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Turbine Building Flood**	3.40E-05	3.40E-05
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Seismic Event**	3.00E-05	3.00E-05
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Tornado**	2.70E-05	2.70E-05
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Turbine Building Fire**	1.70E-05	1.70E-05
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Station Blackout**	1.75E-05	1.75E-05
Flow Diversion of SFP Cooling	Valve or Pipe Failure or Operator Error Diverts SFP Cooling Flow From Deep End	2.6E-4	1.3E-4
Failure of Refueling Cavity Deep-end Drains	Valve Failure or Piping Failure Refueling Cavity is Flooded and the Fuel Transfer Tube is Open	4.0E-7	2.0E-7
SSF Piping Break Causes a Transfer Tube Leak	Valve Failure or Piping Failure of the Transfer Tube or Connecting Piping During Either Power Operation or During Shut Down	1.5E-6	7.5E-7

Table 3 - Recovery Measures for Loss of Spent Fuel Pool Level Analysis

Sequences Description	Recovery Description	Failure to Recover Probability
SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate an **External Flood**	Failure to Provide Makeup to the Spent Fuel Pool (with Fire Truck) prior to Draining and Failure to Recover Plant Systems	5.0E-3
SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Turbine Building Flood**	Failure to Provide Makeup to the Spent Fuel Pool (with Normal Path) prior to Draining	2.5E-3
SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Seismic Event**	Failure to Provide Makeup to the Spent Fuel Pool (with Fire Truck) prior to Draining and Failure to Recover Plant Systems	5.0E-3
SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Tornado**	Failure to Provide Makeup to the Spent Fuel Pool (with Fire Truck) prior to Draining and Failure to Recover Plant Systems	5.0E-3
SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Turbine Building Fire**	Failure to Provide Makeup to the Spent Fuel Pool (with Fire Truck) prior to Draining and Failure to Recover Power to Plant Systems	5.0E-3
SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Station Blackout**	Failure to Provide Makeup to the Spent Fuel Pool (with Fire Truck) prior to Draining and Failure to Recover Power to Plant Systems	2.5E-3
Valve or Pipe Failure or Operator Error Diverts SFP Cooling Flow From Deep End	Failure to Isolate the Leak Location Prior to Draining	1.0E-3
Failure of Refueling Cavity Deep-end Drains	Failure to Isolate the Leak Location Prior to Draining	1.0E-2
SSF Piping Break Causes a Transfer Tube Leak	Failure to Isolate the Leak Location Prior to Draining	1.0E-2

Table 4a- Unit 1/2 Spent Fuel Pool Sequence Frequencies

Scenario Description	**Initiator Description**	**Initiator Frequency (per Yr)**	**Mitigation Discription With Current Configration**	**Failure to Mitigate Probability**	**Sequence Frequncy (per yr)**	**Scenario Frequency (per yr)**
SSF RCMP Suction w/ Failure to Refill	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate an **External Flood**	1.20E-05	Failure to Provide Makeup to the Spent Fuel Pool prior to Draining	5.00E-03	6.00E-08	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Turbine Building Flood**	3.40E-05	Failure to Provide Makeup to the Spent Fuel Pool prior to Draining	2.50E-03	8.50E-08	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Seismic Event**	3.00E-05	Failure to Provide Makeup to the Spent Fuel Pool prior to Draining	5.00E-03	1.50E-07	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Tornado**	2.70E-05	Failure to Provide Makeup to the Spent Fuel Pool prior to Draining	5.00E-03	1.35E-07	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Turbine Building Fire**	1.70E-05	Failure to Provide Makeup to the Spent Fuel Pool prior to Draining	5.00E-03	8.50E-08	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Station Blackout**	1.75E-05	Failure to Provide Makeup to the Spent Fuel Pool prior to Draining	2.50E-03	4.38E-08	**5.59E-07**
Flow Diversion of SFP Cooling	Valve or Pipe Failure or Operator Error Diverts SFP Cooling Flow From Deep End	2.60E-04	Failure to Close SF-1 or SF-2 to Isolate the Leak or Isolate the Leak Location Prior to Draining	1.00E-03	2.60E-07	**2.60E-07**
Failure of Refueling Cavity Deep-end Drains		4.00E-07	Failure to Close SF-1 or SF-2 to Isolate the Leak or Isolate the Leak Location Prior to Draining	1.00E-02	4.00E-09	**4.00E-09**
Transfer Tube Leak		1.50E-06	Failure to Close SF-1 or SF-2 to Isolate the Leak or Isolate the Leak Location Prior to Draining	1.00E-02	1.50E-08	**1.50E-08**
Total						**8.38E-07**

Table 4b- Unit 3 Spent Fuel Pool Sequence Frequencies

Scenario Description	Initiator Description	Initiator Frequency (per Yr)	Mitigation Discription With Current Configration	Failure to Mitigate Probability	Sequence Frequncy (per yr)	Scenario Frequency (per yr)
SSF RCMP Suction w/ Failure to Refill	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate an **External Flood**	1.20E-05	Failure to Provide Makeup to the Spent Fuel Pool prior to Draining	5.00E-03	6.00E-08	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Turbine Building Flood**	3.40E-05	Failure to Provide Makeup to the Spent Fuel Pool prior to Draining	2.50E-03	8.50E-08	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Seismic Event**	3.00E-05	Failure to Provide Makeup to the Spent Fuel Pool prior to Draining	5.00E-03	1.50E-07	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Tornado**	2.70E-05	Failure to Provide Makeup to the Spent Fuel Pool prior to Draining	5.00E-03	1.35E-07	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Turbine Building Fire**	1.70E-05	Failure to Provide Makeup to the Spent Fuel Pool prior to Draining	5.00E-03	8.50E-08	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Station Blackout**	1.75E-05	Failure to Provide Makeup to the Spent Fuel Pool prior to Draining	2.50E-03	4.38E-08	**5.59E-07**
Flow Diversion of SFP Cooling	Valve or Pipe Failure or Operator Error Diverts SFP Cooling Flow From Deep End	1.30E-04	Failure to Close SF-1 or SF-2 to Isolate the Leak or Isolate the Leak Location Prior to Draining	1.00E-03	1.30E-07	**1.30E-07**
Failure of Refueling Cavity Deep-end Drains		2.00E-07	Failure to Close SF-1 or SF-2 to Isolate the Leak or Isolate the Leak Location Prior to Draining	1.00E-02	2.00E-09	**2.00E-09**
Transfer Tube Leak		7.50E-07	Failure to Close SF-1 or SF-2 to Isolate the Leak or Isolate the Leak Location Prior to Draining	1.00E-02	7.50E-09	**7.50E-09**
Total						**6.98E-07**

Table 5a - UNIT 1/2 Spent Fuel Pool
Proposed Modification 1 - Add Motor Operators to SF-1 and SF-2

Scenario Description	Initiator Description	Sequence Frequency (per yr)	Sequence Reduction Factor with Improved Configuration	Sequence Frequncy with Improved Configuration (per yr)	Change in Sequence Frequency (per yr)	Change in Scenario Frequency (per yr)
SSF RCMP Suction w/ Failure to Refill	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate an **External Flood**	6.00E-08	1	6.00E-08	0.00E+00	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Turbine Building Flood**	8.50E-08	1	8.50E-08	0.00E+00	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Seismic Event**	1.50E-07	1	1.50E-07	0.00E+00	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Tornado**	1.35E-07	1	1.35E-07	0.00E+00	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Turbine Building Fire**	8.50E-08	1	8.50E-08	0.00E+00	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Station Blackout**	4.38E-08	1	4.38E-08	0.00E+00	0.00E+00
Flow Diversion of SFP Cooling	Valve or Pipe Failure or Operator Error Diverts SFP Cooling Flow From Deep End	2.60E-07	1	2.60E-07	0.00E+00	0.00E+00
Failure of Refueling Cavity Deep-end Drains		4.00E-09	1	4.00E-09	0.00E+00	0.00E+00
Tranfser Tube Leak		1.50E-08	10	1.50E-09	1.35E-08	1.35E-08
Total						1.35E-08

Table 5b - UNIT 3 Spent Fuel Pool
Proposed Modification 1 - Add Motor Operators to SF-1 and SF-2

Scenario Description	**Initiator Description**	**Sequence Frequency (per yr)**	**Sequence Reduction Factor with Improved Configuration**	**Sequence Frequncy with Improved Configuration (per yr)**	**Change in Sequence Frequency (per yr)**	**Change in Scenario Frequency (per yr)**
SSF RCMP Suction w/ Failure to Refill	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate an **External Flood**	6.00E-08	1	6.00E-08	0.00E+00	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Turbine Building Flood**	8.50E-08	1	8.50E-08	0.00E+00	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Seismic Event**	1.50E-07	1	1.50E-07	0.00E+00	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Tornado**	1.35E-07	1	1.35E-07	0.00E+00	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Turbine Building Fire**	8.50E-08	1	8.50E-08	0.00E+00	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Station Blackout**	4.38E-08	1	4.38E-08	0.00E+00	0.00E+00
Flow Diversion of SFP Cooling	Valve or Pipe Failure or Operator Error Diverts SFP Cooling Flow From Deep End	1.30E-07	1	1.30E-07	0.00E+00	0.00E+00
Failure of Refueling Cavity Deep-end Drains		2.00E-09	1	2.00E-09	0.00E+00	0.00E+00
Tranfser Tube Leak		7.50E-09	10	7.50E-10	6.75E-09	6.75E-09
Total						6.75E-09

Table 6a - UNIT 1/2 Spent Fuel Pool
Proposed Modification 2 - Add a Standpipe for SSF Suction

Scenario Description	Initiator Description	Sequence Frequency (per yr)	Sequence Reduction Factor with Improved Configuration	Sequence Frequncy with Improved Configuration (per yr)	Change in Sequence Frequency (per yr)	Change in Scenario Frequency (per yr)
SSF RCMP Suction w/ Failure to Refill	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate an **External Flood**	6.00E-08	1.03	5.83E-08	1.75E-09	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Turbine Building Flood**	8.50E-08	1.03	8.25E-08	2.48E-09	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Seismic Event**	1.50E-07	1.03	1.46E-07	4.37E-09	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Tornado**	1.35E-07	1.03	1.31E-07	3.93E-09	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Turbine Building Fire**	8.50E-08	1.03	8.25E-08	2.48E-09	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Station Blackout**	4.38E-08	1.03	4.25E-08	1.27E-09	1.63E-08
Flow Diversion of SFP Cooling	Valve or Pipe Failure or Operator Error Diverts SFP Cooling Flow From Deep End	2.60E-07	1	2.60E-07	0.00E+00	0.00E+00
Failure of Refueling Cavity Deep-end Drains		4.00E-09	1	4.00E-09	0.00E+00	0.00E+00
Tranfser Tube Leak		1.50E-08	10	1.50E-09	1.35E-08	1.35E-08
Total						2.98E-08

Table 6b - UNIT 3 Spent Fuel Pool
Proposed Modification 2 - Add a Standpipe for SSF Suction

Scenario Description	**Initiator Description**	**Sequence Frequency (per yr)**	**Sequence Reduction Factor with Improved Configuration**	**Sequence Frequncy with Improved Configuration (per yr)**	**Change in Sequence Frequency (per yr)**	**Change in Scenario Frequency (per yr)**
SSF RCMP Suction w/ Failure to Refill	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate an **External Flood**	6.00E-08	1.03	5.83E-08	1.75E-09	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Turbine Building Flood**	8.50E-08	1.03	8.25E-08	2.48E-09	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Seismic Event**	1.50E-07	1.03	1.46E-07	4.37E-09	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Tornado**	1.35E-07	1.03	1.31E-07	3.93E-09	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Turbine Building Fire**	8.50E-08	1.03	8.25E-08	2.48E-09	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Station Blackout**	4.38E-08	1.03	4.25E-08	1.27E-09	1.63E-08
Flow Diversion of SFP Cooling	Valve or Pipe Failure or Operator Error Diverts SFP Cooling Flow From Deep End	1.30E-07	1	1.30E-07	0.00E+00	0.00E+00
Failure of Refueling Cavity Deep-end Drains		2.00E-09	1	2.00E-09	0.00E+00	0.00E+00
Tranfser Tube Leak		7.50E-09	10	7.50E-10	6.75E-09	6.75E-09
Total						2.30E-08

Table 7a - UNIT 1/2 Spent Fuel Pool
Proposed Modification 3 - Add Weir Walls to the Spent Fuel Pool

Scenario Description	Initiator Description	Sequence Frequency (per yr)	Sequence Reduction Factor with Improved Configuration	Sequence Frequncy with Improved Configuration (per yr)	Change in Sequence Frequency (per yr)	Change in Scenario Frequency (per yr)
SSF RCMP Suction w/ Failure to Refill	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate an **External Flood**	6.00E-08	1.03	5.83E-08	1.75E-09	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Turbine Building Flood**	8.50E-08	1.03	8.25E-08	2.48E-09	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Seismic Event**	1.50E-07	1.03	1.46E-07	4.37E-09	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Tornado**	1.35E-07	1.03	1.31E-07	3.93E-09	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Turbine Building Fire**	8.50E-08	1.03	8.25E-08	2.48E-09	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Station Blackout**	4.38E-08	1.03	4.25E-08	1.27E-09	1.63E-08
Flow Diversion of SFP Cooling	Valve or Pipe Failure or Operator Error Diverts SFP Cooling Flow From Deep End	2.60E-07	10	2.60E-08	2.34E-07	2.34E-07
Failure of Refueling Cavity Deep-end Drains		4.00E-09	100	4.00E-11	3.96E-09	3.96E-09
Tranfser Tube Leak		1.50E-08	100	1.50E-10	1.49E-08	1.49E-08
Total						2.69E-07

Table 7b - UNIT 3 Spent Fuel Pool
Proposed Modification 3 - Add Weir Walls to the Spent Fuel Pool

Scenario Description	**Initiator Description**	**Sequence Frequency (per yr)**	**Sequence Reduction Factor with Improved Configuration**	**Sequence Frequncy with Improved Configuration (per yr)**	**Change in Sequence Frequency (per yr)**	**Change in Scenario Frequency (per yr)**
SSF RCMP Suction w/ Failure to Refill	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate an **External Flood**	6.00E-08	1.03	5.83E-08	1.75E-09	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Turbine Building Flood**	8.50E-08	1.03	8.25E-08	2.48E-09	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Seismic Event**	1.50E-07	1.03	1.46E-07	4.37E-09	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Tornado**	1.35E-07	1.03	1.31E-07	3.93E-09	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Turbine Building Fire**	8.50E-08	1.03	8.25E-08	2.48E-09	
	SSF RCMP Suction from Fuel Transfer Tube is Needed to Mitigate a **Station Blackout**	4.38E-08	1.03	4.25E-08	1.27E-09	1.63E-08
Flow Diversion of SFP Cooling	Valve or Pipe Failure or Operator Error Diverts SFP Cooling Flow From Deep End	1.30E-07	10	1.30E-08	1.17E-07	1.17E-07
Failure of Refueling Cavity Deep-end Drains		2.00E-09	100	2.00E-11	1.98E-09	1.98E-09
Tranfser Tube Leak		7.50E-09	100	7.50E-11	7.43E-09	7.43E-09
Total						1.43E-07

Table 8

Oconee Units 1/2 Spent Fuel Pool Inventory

Batch Number	Discharge Date	Cycles of Operation	Number of Fuel Assemblies	Average Burnup (mwd/mtu)
5	4/7/76	1	2	12,538
7	5/28/77	2	19	23,284
12	5/28/77	2	12	20,394
13	6/6/78	3	21	24,120
15	9/2/78	3	4	29,660
18	11/4/78	3	4	25,683
23	11/21/79	2	3	18,601
24	11/21/79	4	1	39,894
27	3/4/80	3	1	30,556
30	12/5/80	3	15	25,023
33	6/26/81	2	16	24,587
35	12/29/81	3	1	33,884
37	12/29/81	2	9	21,543
38	12/29/81	1	1	14,140
41	4/24/82	2	19	21,229
43	6/1/83	3	1	29,988
44	6/1/83	2	1	27,864
45	6/1/83	5	1	50,598
46	9/14/83	3	3	31,010
47	9/14/83	2	20	26,653
51	10/5/84	3	16	36,395
52	10/5/84	2	3	28,613
53	10/5/84	1	1	13,916
56	2/21/85	3	8	35,879
57	2/21/85	2	3	28,777
62	2/13/86	3	46	36,208
63	2/13/86	2	2	30,510
70	8/16/86	3	37	35,618
71	8/16/86	2	3	31,888
77	9/2/87	3	52	37,618
78	9/2/87	2	4	30,134
86	2/2/88	3	36	38,221
87	2/2/88	2	16	31,496
97	1/3/89	4	1	58,310
98	1/3/89	3	48	36,815
99	1/3/89	2	3	31,971
103	5/20/89	4	13	39,697
104	5/20/89	3	28	38,117
105	5/20/89	2	2	30,126

Table 8 (cont'd)

Oconee Units 1/2 Spent Fuel Pool Inventory

Batch Number	Discharge Date	Cycles of Operation	Number of Fuel Assemblies	Average Burnup (mwd/mtu)
120	4/26/90	4	8	41,383
121	4/26/90	3	29	39,229
122	4/26/90	2	15	32,113
129	9/12/90	4	16	31,383
130	9/12/90	3	29	40,290
131	9/12/90	2	3	23,343
141	8/1/91	4	28	35,529
142	8/1/91	3	37	40,234
149	1/9/92	4	20	36,034
150	1/9/92	3	53	41,716
158	12/3/92	3	9	34,774
159	12/3/92	3	4	41,961
160	12/3/92	4	8	44,924
161	12/3/92	3	35	42,319
169	4/29/93	3	8	35,849
170	4/29/93	3	9	35,977
171	4/29/93	3	4	36,822
172	4/29/93	3	36	43,412
173	4/29/93	2	3	35,106
183	4/28/94	4	17	44,249
184	4/28/94	3	37	42,198
185	4/28/94	2	5	31,836
193	10/6/94	4	16	41,737
194	10/6/94	3	29	44,358
195	10/6/94	2	15	33,072
209	11/2/95	4	15	38,429
210	11/2/95	3	38	43,280
211	11/2/95	2	8	37,942
214	3/28/96	4	20	42,595
215	3/28/96	3	29	41,808
216	3/28/96	2	11	37,554
off-load*	3/28/96	3	8	40,176
off-load*	3/28/96	2	49	34,330
off-load*	3/28/96	1	60	19,076
Total Assemblies			**1187**	

* Off-load assemblies are assumed to be in the SFP for times less than 35 days. After this time, the assemblies are assumed to be reloaded into the core.

Table 9

Oconee 1/2 SFP Activity Released (Ci) - < 2yr Zircaloy, > 2yr Gap (NUREG/CR-4982 Release Fractions for Zircaloy Fire & NUREG 1465 Gap Fractions)

Isotope	Days After Shutdown					
	10	20	35	50	125	200
AM241	5.65E-02	5.70E-02	6.58E-02	5.88E-02	6.14E-02	7.07E-02
BA140	1.43E+05	8.33E+04	3.69E+04	3.63E+03	8.18E+01	3.17E+00
CE141	9.68E+01	7.86E+01	5.62E+01	9.50E+00	2.17E+00	6.01E-01
CE143	6.94E-01	4.49E-03	2.33E-06	2.64E-10	1.25E-25	9.12E-39
CE144	1.22E+02	1.20E+02	1.09E+02	5.01E+01	4.47E+01	3.46E+01
CM242	5.14E+00	5.00E+00	4.27E+00	2.69E+00	2.14E+00	1.47E+00
CM244	1.38E+00	1.38E+00	1.36E+00	1.17E+00	1.16E+00	1.15E+00
CO 58	7.92E+04	7.20E+04	6.25E+04	2.13E+04	1.04E+04	5.13E+03
CO 60	6.69E+04	6.67E+04	6.63E+04	4.26E+04	4.14E+04	4.03E+04
CS134	3.34E+07	3.33E+07	3.12E+07	2.32E+07	2.24E+07	2.01E+07
CS136	2.44E+06	1.44E+06	6.51E+05	1.00E+05	2.47E+03	1.03E+02
CS137	2.30E+07	2.30E+07	2.29E+07	1.78E+07	1.77E+07	1.76E+07
I131	3.12E+07	1.32E+07	3.61E+06	2.30E+05	5.51E+02	3.13E+00
I132	1.25E+07	1.48E+06	6.10E+04	5.77E+02	1.97E-04	5.62E-10
I133	4.95E+04	1.66E+01	1.03E-04	1.43E-10	6.93E-35	0.00E+00
I134	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I135	1.59E-03	1.88E-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR 85	1.83E+06	1.83E+06	1.80E+06	1.34E+06	1.33E+06	1.31E+06
KR 85M	1.32E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR 87	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR 88	4.07E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LA140	8.22E+01	4.79E+01	2.12E+01	2.09E+00	4.71E-02	1.82E-03
MO 99	1.07E+01	8.63E-01	1.97E-02	1.04E-04	2.25E-12	6.09E-19
NB 95	1.30E+06	1.27E+06	1.14E+06	2.89E+05	1.71E+05	9.05E+04
ND147	2.51E+01	1.34E+01	5.23E+00	4.61E-01	5.73E-03	1.33E-04
NP239	8.53E+01	4.50E+00	6.10E-02	5.70E-03	5.53E-03	5.53E-03
PR143	6.90E+01	4.15E+01	1.93E+01	1.94E+00	5.44E-02	2.53E-03
PU238	8.58E-01	8.59E-01	8.61E-01	7.23E-01	7.25E-01	7.27E-01
PU239	6.55E-02	6.56E-02	6.56E-02	4.62E-02	4.62E-02	4.62E-02
PU240	1.03E-01	1.03E-01	1.04E-01	7.92E-02	7.92E-02	7.92E-02
PU241	2.49E+01	2.49E+01	2.46E+01	1.79E+01	1.78E+01	1.75E+01
RB 86	1.08E+05	7.49E+04	4.26E+04	8.24E+03	6.14E+02	6.61E+01
RH105	1.57E+01	1.42E-01	1.23E-04	2.83E-08	1.41E-22	7.79E-35
RU103	1.98E+03	1.67E+03	1.25E+03	2.59E+02	7.71E+01	2.64E+01
RU105	8.87E-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RU106	1.42E+03	1.41E+03	1.28E+03	7.63E+02	7.03E+02	5.72E+02
SB127	1.37E+06	2.27E+05	1.52E+04	2.56E+02	8.60E-04	1.75E-08
SB129	4.54E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SR 89	9.54E+04	8.33E+04	6.74E+04	4.56E+03	1.82E+03	7.66E+02
SR 90	2.71E+04	2.71E+04	2.69E+04	1.98E+04	1.97E+04	1.96E+04
SR 91	3.94E-03	9.78E-11	3.70E-20	0.00E+00	0.00E+00	0.00E+00
TC 99M	1.68E+02	1.35E+01	3.42E-01	3.37E-02	3.31E-02	3.31E-02
TE127	5.02E+04	2.72E+04	2.01E+04	6.61E+03	4.54E+03	2.77E+03
TE127M	2.45E+04	2.33E+04	2.02E+04	6.74E+03	4.63E+03	2.83E+03
TE129	3.80E+04	3.11E+04	2.24E+04	4.21E+03	1.01E+03	2.92E+02
TE129M	5.83E+04	4.77E+04	3.44E+04	6.47E+03	1.56E+03	4.49E+02
TE131M	8.27E+02	3.23E+00	7.89E-04	4.57E-08	6.34E-25	3.05E-39
TE132	2.42E+05	2.88E+04	1.18E+03	1.12E+01	3.82E-06	1.09E-11
XE133	4.54E+07	1.22E+07	1.68E+06	5.24E+04	5.03E+00	1.81E-03
XE135	4.49E+00	5.06E-08	1.88E-17	0.00E+00	0.00E+00	0.00E+00
Y 90	2.71E+04	2.71E+04	2.69E+04	1.98E+04	1.97E+04	1.96E+04
Y 91	1.56E+05	1.39E+05	1.14E+05	2.19E+04	1.00E+04	4.72E+03
ZR 95	1.12E+06	1.01E+06	8.36E+05	1.85E+05	9.11E+04	4.51E+04
ZR 97	6.24E+01	3.31E-03	1.28E-09	1.10E-16	0.00E+00	0.00E+00

Table 10

Oconee 1/2 SFP Activity Released (Ci) - Zircaloy Fire in all Fuel Assemblies (Using NUREG/CR-4982 Release Fractions)

Isotope	Days After Shutdown					
	10	20	35	50	125	200
AM241	7.61E-01	7.61E-01	7.82E-01	7.75E-01	7.81E-01	8.09E-01
BA140	1.43E+05	8.33E+04	3.69E+04	3.63E+03	8.18E+01	3.17E+00
CE141	9.68E+01	7.86E+01	5.62E+01	9.50E+00	2.17E+00	6.01E-01
CE143	6.94E-01	4.49E-03	2.33E-06	2.64E-10	1.25E-25	9.12E-39
CE144	1.29E+02	1.27E+02	1.14E+02	5.49E+01	4.95E+01	3.88E+01
CM242	5.26E+00	5.12E+00	4.33E+00	2.74E+00	2.19E+00	1.52E+00
CM244	4.57E+00	4.57E+00	4.54E+00	4.34E+00	4.33E+00	4.28E+00
CO 58	7.92E+04	7.20E+04	6.25E+04	2.13E+04	1.04E+04	5.13E+03
CO 60	1.33E+05	1.32E+05	1.32E+05	1.08E+05	1.05E+05	1.02E+05
CS134	4.90E+07	4.89E+07	4.53E+07	3.73E+07	3.63E+07	3.30E+07
CS136	2.44E+06	1.44E+06	6.51E+05	1.00E+05	2.47E+03	1.03E+02
CS137	6.70E+07	6.70E+07	6.67E+07	6.16E+07	6.15E+07	6.11E+07
I131	3.12E+07	1.32E+07	3.61E+06	2.30E+05	5.51E+02	3.13E+00
I132	1.25E+07	1.48E+06	6.10E+04	5.77E+02	1.97E-04	5.62E-10
I133	4.95E+04	1.66E+01	1.03E-04	1.43E-10	6.93E-35	0.00E+00
I134	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I135	1.59E-03	1.88E-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR 85	4.53E+06	4.53E+06	4.48E+06	4.02E+06	4.00E+06	3.93E+06
KR 85M	1.32E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR 87	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR 88	4.07E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LA140	8.22E+01	4.79E+01	2.12E+01	2.09E+00	4.71E-02	1.82E-03
MO 99	1.07E+01	8.63E-01	1.97E-02	1.04E-04	2.25E-12	6.09E-19
NB 95	1.30E+06	1.27E+06	1.14E+06	2.89E+05	1.71E+05	9.05E+04
ND147	2.51E+01	1.34E+01	5.23E+00	4.61E-01	5.73E-03	1.33E-04
NP239	8.53E+01	4.52E+00	7.98E-02	2.46E-02	2.44E-02	2.44E-02
PR143	6.90E+01	4.15E+01	1.93E+01	1.94E+00	5.44E-02	2.53E-03
PU238	3.26E+00	3.26E+00	3.26E+00	3.12E+00	3.12E+00	3.12E+00
PU239	2.25E-01	2.25E-01	2.25E-01	2.06E-01	2.06E-01	2.06E-01
PU240	3.77E-01	3.77E-01	3.78E-01	3.53E-01	3.53E-01	3.53E-01
PU241	7.14E+01	7.14E+01	7.08E+01	6.41E+01	6.39E+01	6.30E+01
RB 86	1.08E+05	7.49E+04	4.26E+04	8.24E+03	6.14E+02	6.61E+01
RH105	1.57E+01	1.42E-01	1.23E-04	2.83E-08	1.41E-22	7.79E-35
RU103	1.98E+03	1.67E+03	1.25E+03	2.59E+02	7.71E+01	2.64E+01
RU105	8.87E-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RU106	1.61E+03	1.60E+03	1.42E+03	9.07E+02	8.45E+02	6.99E+02
SB127	1.37E+06	2.27E+05	1.52E+04	2.56E+02	8.60E-04	1.75E-08
SB129	4.54E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SR 89	9.54E+04	8.33E+04	6.74E+04	4.56E+03	1.82E+03	7.66E+02
SR 90	8.61E+04	8.61E+04	8.58E+04	7.86E+04	7.85E+04	7.80E+04
SR 91	3.94E-03	9.78E-11	3.70E-20	0.00E+00	0.00E+00	0.00E+00
TC 99M	1.68E+02	1.37E+01	4.53E-01	1.44E-01	1.44E-01	1.44E-01
TE127	5.03E+04	2.72E+04	2.01E+04	6.62E+03	4.55E+03	2.78E+03
TE127M	2.45E+04	2.34E+04	2.03E+04	6.75E+03	4.64E+03	2.84E+03
TE129	3.80E+04	3.11E+04	2.24E+04	4.21E+03	1.01E+03	2.92E+02
TE129M	5.83E+04	4.77E+04	3.44E+04	6.47E+03	1.56E+03	4.49E+02
TE131M	8.27E+02	3.23E+00	7.89E-04	4.57E-08	6.34E-25	3.05E-39
TE132	2.42E+05	2.88E+04	1.18E+03	1.12E+01	3.82E-06	1.09E-11
XE133	4.54E+07	1.22E+07	1.68E+06	5.24E+04	5.03E+00	1.81E-03
XE135	4.49E+00	5.06E-08	1.88E-17	0.00E+00	0.00E+00	0.00E+00
Y 90	8.60E+04	8.59E+04	8.56E+04	7.84E+04	7.83E+04	7.77E+04
Y 91	1.56E+05	1.40E+05	1.14E+05	2.22E+04	1.03E+04	4.94E+03
ZR 95	1.12E+06	1.01E+06	8.36E+05	1.85E+05	9.11E+04	4.51E+04
ZR 97	6.24E+01	3.31E-03	1.28E-09	1.78E-16	6.78E-17	6.78E-17

Table 11

Release Fractions for Oconee SFP Off-Site Radiological Consequences Analysis

Isotope Group	Release Fraction Zircaloy Fire[1]	Release Fraction Gap Release[2]
Cs, I, Kr, Rb Xe	1.00	0.05
Sb	1.00	0.00
Co-60	0.12	0.00
Co-58	0.10	0.00
Te	0.02	0.00
Nb, Zr	0.01	0.00
Ba, SR, Y	0.002	0.00
Rh, Ru, Tc	2.0E-05	0.00
Am, Ce, Cm, La, Mo, Nd, Np, Pr, Pu	1.0E-06	0.00

1. NUREG/CR 4982
2. NUREG -1465

Table 12

Estimated Off-Site Consequences Following Uncovering Spent Fuel At Oconee Nuclear Station

Spent Fuel Damage Category	Whole-Body Person-REM
1. Oconee 1/2 SFP Inventory - Zircaloy Fire in Fuel < 2 yr., Gap Release in Remaining Fuel	8.4E+06
2. Oconee 1/2 SFP Inventory - Zircaloy Fire in all Fuel Assemblies	9.0E+06
3. NUREG/CR-4982, Table 4.3 - 30 Day Inventory, Zircaloy Fire Throughout Pool	8.3E+06
4. NUREG/CR-4982, Table 4.4 - 90 Day Inventory, Zircaloy Fire in Last Discharged Fuel Batch	6.0E+06

Table 13 - Conditional Risk of Spent Fuel Pool Accident

Cost per Person-Rem ($) = $2,000

	Low Estimate	Worst Case
Conditional Public Health Consequences (Person-Rem)	6.00E+06	9.00E+06
Conditional Cost of Health Effects ($)	1.20E+10	1.80E+10
Conditional Cost of Offsite Property Damage ($)	3.50E+09	3.00E+10
Total Cost of Spent Fuel Pool Accident	1.55E+10	4.80E+10

Table 14a - Unit 1/2 Spent Fuel Pool
Proposed Modification 1 - Add Motor Operators to SF-1 and SF-2

Scenario Description	Averted Sequence Frequency (per yr)	Low Estimate Risk Weighted Cost ($/yr)	Low Estimate Risk Weighted Present Value of Cost for Life of Plant ($)	Worst Case Risk Weighted Cost ($/yr)	Worst Case Risk Weighted Present Value of Cost for Life of Plant ($)
SSF Sequences	0.00E+00	$0	$0	$0	$0
Flow Diversion	0.00E+00	$0	$0	$0	$0
Deep-end Drains	0.00E+00	$0	$0	$0	$0
Tranfser Tube Leak	1.35E-08	$209	$2,289	$648	$7,089
Total Risk Weighted Cost of Spent Fuel Pool Accidents	1.35E-08	$209	$2,289	$648	$7,089

Table 14b - Unit 3 Spent Fuel Pool
Proposed Modification 1 - Add Motor Operators to SF-1 and SF-2

Scenario Description	Averted Sequence Frequency (per yr)	Low Estimate Risk Weighted Cost ($/yr)	Low Estimate Risk Weighted Present Value of Cost for Life of Plant ($)	Worst Case Risk Weighted Cost ($/yr)	Worst Case Risk Weighted Present Value of Cost for Life of Plant ($)
SSF Sequences	0.00E+00	$0	$0	$0	$ -
Flow Diversion	0.00E+00	$0	$0	$0	$ -
Deep-end Drains	0.00E+00	$0	$0	$0	$ -
Tranfser Tube Leak	6.75E-09	$105	$1,145	$324	$ 3,544
Total Risk Weighted Cost of Spent Fuel Pool Accidents	6.75E-09	$105	$1,145	$324	$ 3,544

Table 15a - Unit 1/2 Spent Fuel Pool
Proposed Modification 2 - Add a Standpipe for SSF Suction

Scenario Description	Averted Sequence Frequency (per yr)	Low Estimate Risk Weighted Cost ($/yr)	Low Estimate Risk Weighted Present Value of Cost for Life of Plant ($)	Worst Case Risk Weighted Cost ($/yr)	Worst Case Risk Weighted Present Value of Cost for Life of Plant ($)
SSF Sequences	1.63E-08	$252	$2,759	$781	$8,546
Flow Diversion	0.00E+00	$0	$0	$0	$0
Deep-end Drains	0.00E+00	$0	$0	$0	$0
Tranfser Tube Leak	1.35E-08	$209	$2,289	$648	$7,089
Total Risk Weighted Cost of Spent Fuel Pool Accidents	2.98E-08	$462	$5,049	$1,429	$15,634

Table 15b - Unit 3 Spent Fuel Pool
Proposed Modification 2 - Add a Standpipe for SSF Suction

Scenario Description	Averted Sequence Frequency (per yr)	Low Estimate Risk Weighted Cost ($/yr)	Low Estimate Risk Weighted Present Value of Cost for Life of Plant ($)	Worst Case Risk Weighted Cost ($/yr)	Worst Case Risk Weighted Present Value of Cost for Life of Plant ($)
SSF Sequences	1.63E-08	$252	$2,759	$781	$8,546
Flow Diversion	0.00E+00	$0	$0	$0	$0
Deep-end Drains	0.00E+00	$0	$0	$0	$0
Tranfser Tube Leak	6.75E-09	$105	$1,145	$324	$3,544
Total Risk Weighted Cost of Spent Fuel Pool Accidents	2.30E-08	$357	$3,904	$1,105	$12,090

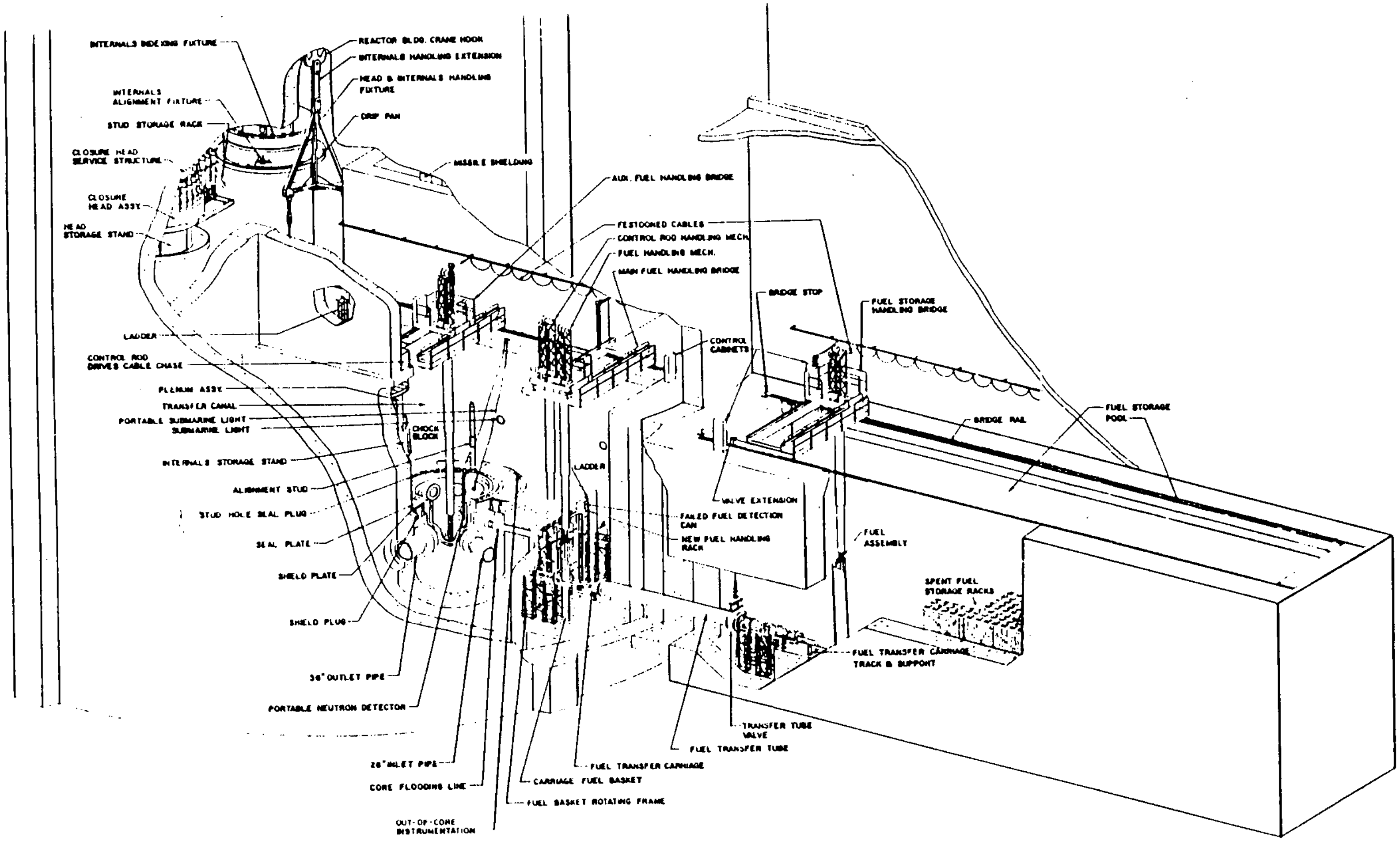
Table 16a - Unit 1/2 Spent Fuel Pool
Proposed Modification 3 - Add Weir Walls to the Spent Fuel Pool

Scenario Description	Averted Sequence Frequency (per yr)	Low Estimate Risk Weighted Cost ($/yr)	Low Estimate Risk Weighted Present Value of Cost for Life of Plant ($)	Worst Case Risk Weighted Cost ($/yr)	Worst Case Risk Weighted Present Value of Cost for Life of Plant ($)
SSF Sequences	1.63E-08	$252	$2,759	$781	$8,546
Flow Diversion	2.34E-07	$3,627	$39,677	$11,232	$122,872
Deep-end Drains	3.96E-09	$61	$671	$190	$2,079
Tranfser Tube Leak	1.49E-08	$230	$2,518	$713	$7,798
Total Risk Weighted Cost of Spent Fuel Pool Accidents	2.69E-07	$4,171	$45,626	$12,916	$141,294

Table 16b - Unit 3 Spent Fuel Pool
Proposed Modification 3 - Add Weir Walls to the Spent Fuel Pool

Scenario Description	Averted Sequence Frequency (per yr)	Low Estimate Risk Weighted Cost ($/yr)	Low Estimate Risk Weighted Present Value of Cost for Life of Plant ($)	Worst Case Risk Weighted Cost ($/yr)	Worst Case Risk Weighted Present Value of Cost for Life of Plant ($)
SSF Sequences	1.63E-08	$252	$2,759	$781	$8,546
Flow Diversion	1.17E-07	$1,814	$19,839	$5,616	$61,436
Deep-end Drains	1.98E-09	$31	$336	$95	$1,040
Tranfser Tube Leak	7.43E-09	$115	$1,259	$356	$3,899
Total Risk Weighted Cost of Spent Fuel Pool Accidents	1.43E-07	$2,212	$24,193	$6,849	$74,920

Figure 1 - Trimetric of the Refueling System



OTC CONTROL COPY

TITLE:	NOTES:	ID NO: OC-FH-FHS-01	DATE: 6-4-84
TRIMETRIC OF THE REFUELING SYSTEM		REF: B&W	
		DRN. BY: TAL:BB	APR. BY: RDB
		TRAINING USE ONLY	

Figure 2 - Summ[illegible] Flow Diagram of Spent Fue[illegible]oling System