PRAIRIE ISLAND

SPENT FUEL POOL DILUTION ANALYSIS

February 1997

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PRAIRIE ISLAND
SPENT FUEL POOL BORON DILUTION ANALYSIS

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1.0 INTRODUCTION

A boron dilution analysis has been completed for crediting boron in the Prairie Island spent fuel rack criticality analysis. The boron dilution analysis includes an evaluation of the following plant specific features:

- Dilution Sources
- Boration Sources
- Instrumentation
- Administrative Procedures
- Piping
- Loss of Offsite Power Impact
- Boron Dilution Initiating Events
- Boron Dilution Times and Volumes

The boron dilution analysis was completed to ensure that sufficient time is available to detect and mitigate the dilution before the spent fuel rack criticality analysis 0.95 k_{eff} design basis is exceeded.

2.0 SPENT FUEL POOL AND RELATED SYSTEM FEATURES

This section provides background information on the spent fuel pool and its related systems and features. A one-line diagram of the spent fuel pool related systems is provided as Figure 2-1.

2.1 Spent Fuel Pool

The design purpose of the spent fuel pool is to provide for the safe storage of irradiated fuel assemblies. The pool is filled with borated water. The water functions to remove decay heat, provide shielding for personnel handling the fuel, and to reduce the amount of radioactive gases released during a fuel handling accident. Pool water evaporation takes place on a continuous basis, requiring periodic makeup. The makeup source can be unborated water, since the evaporation process does not carry off the boron. Evaporation actually increases the boron concentration in the pool.

The spent fuel pool is a reinforced concrete structure with a minimum 3/16 inch welded steel liner. The water tight liner has special leakage channels to collect and detect liner leakage. The pool structure is designed to meet seismic requirements. The pool is approximately 39 feet deep. The top of the pool is on the fourth floor of the plant auxiliary building.

The Prairie Island spent fuel pool is divided into two pools. The larger pool is used only for the storage of fuel and the smaller pool is used for storage of fuel and for loading of fuel storage or transportation casks. A transfer canal lies adjacent to the two pools and connects to the reactor refueling water cavity during refueling operations. The two pools and the transfer canal are connected by fuel transfer slots that can be closed by pneumatically sealed gates. The elevation of the slot bottoms are above the elevation of the top of the active fuel in the spent fuel storage racks.

The elevation of the top of the gates, when installed, is approximately two feet below the floor level of the spent fuel pool area. The removable gates are designed to support the full height of water remaining on either side after the other is completely drained.

The gates between the pools and the transfer canal, and between the large and small pools are normally removed. The total volume of water contained in the small pool, large pool and transfer canal is approximately 395,000 gallons when they are filled to the elevation associated with the pool low level alarm. When isolated from the large pool and the transfer canal, the small pool contains approximately 91,000 gallons when filled to the elevation associated with the pool low level alarm.

2.2 Spent Fuel Storage Racks

The spent fuel racks are designed to support and protect the spent fuel assemblies under normal and credible accident conditions. Their structural strength ensures the ability to withstand combinations of dead loads, live loads (fuel assemblies), and safe shutdown earthquake loads.

2.3 Spent Fuel Pool Cooling System

The spent fuel pool cooling system is designed to remove, from the shared spent fuel pool, the heat generated by stored spent fuel elements. System design does not incorporate redundant active components except for the spent fuel pool pump and heat exchanger. Alternate cooling capability can be made available under anticipated malfunctions or failures. System piping is so arranged that failure of any pipeline does not drain the spent fuel pool below the top of the stored spent fuel assemblies.

The system is capable of handling a maximum heat load corresponding to both pools

being filled with a combined total of 1362 normally discharged fuel assemblies plus a freshly off loaded core consisting of 121 fuel assemblies.

The portion of the spent fuel pool cooling system which if it failed could result in a significant release of pool water is seismically designed.

Each of the two trains of the cooling system consists of a pump, a heat exchanger, valves, piping and instrumentation. The pump takes suction from the fuel pool at an inlet located below the pool water level, transfers the pool water through a heat exchanger and returns it back into the pool through an outlet located below and a large distance away from the cooling system inlet. The return line is designed to prevent siphoning. The heat exchangers are cooled by component cooling water.

2.4 Spent Fuel Pool Cleanup System

The spent fuel pool cleanup system is designed to maintain water clarity and to control borated water chemistry. The cleanup system is connected to the spent fuel pool cooling system. About 60 gpm of the spent fuel pool cooling pump(s) discharge flow can be diverted to the cleanup loop, which includes the spent fuel pool demineralizer and filters. The filters remove particulates from the spent fuel pool water and the spent fuel pool demineralizer removes ionic impurities.

The refueling water purification loop also uses the spent fuel pool demineralizer and filters to clean up the refueling water storage tank after refueling operations. The flow rate in the loop is limited to 60 gpm to accommodate the design flow of the spent fuel pool demineralizer.

The spent fuel pool has a surface skimmer system designed to provide optical clarity by removing surface debris. The system consists of two surface skimmers, a single

strainer, a single pump and one filter. The skimmer pump is a centrifugal pump with a 100 gpm capacity. The pump discharge flow passes through the filter to remove particulates. It returns to the spent fuel pool.

2.5 Dilution Sources

2.5.1 Chemical and Volume Control System (CVCS)

The Chemical and Volume Control System (CVCS) connects directly with the spent fuel pool cooling system at four locations. The first connection is a four inch line from the inlet of the 121 spent fuel pool heat exchanger to the CVCS holdup tank. This connection is normally isolated and is used to transfer water from the spent fuel pool to the CVCS system. The isolation is normally by one of three manual valves.

There is no check valve between the CVCS holdup tank and this connection to the spent fuel pool cooling system, however, it is not credible that water would back up from the tank to the spent fuel pool cooling system. In the situation where the CVCS holdup tank is misaligned to the spent fuel pool through this connection, water from the spent fuel pool cooling system would flow to the tank. Thus, this path would only result in the loss of water from the pool if the normally closed valve were to fail or be left open. The holdup tanks also have a high level alarm which alarms in the control room.

The second connection between the spent fuel pool and the CVCS is from the Unit 1 boric acid blender. This connection is used to supply water (reactor makeup water blended with borated water) at a specific boron concentration to the pools. Reactor makeup water and concentrated boric acid are supplied to the blender at pre-determined flow rates to generate water at a desired boron concentration. The connection is on the down stream side of the boric acid blender and is isolated by two

manual valves. One valve is a normally closed valve that isolates a common line that supplies the spent fuel pool cooling system, the refueling water storage tank (RWST), or the CVCS holdup tanks. The other valve is a normally closed valve that isolates the spent fuel pool cooling system from the CVCS. The supply from the blender to the spent fuel pool cooling system can have a boron concentration from 0 to 21,000 ppm depending on the control setting for the blender. This connection is a source of makeup water if the pools are losing inventory.

When delivering blended flow, this connection can deliver a flow rate of approximately 100 gpm to the spent fuel pool. If only reactor makeup water is being supplied to the blender, the flow to the spent fuel pool would be limited by the capability of the reactor makeup water system to approximately 80 gpm.

The third connection between the spent fuel pool and the CVCS is from the CVCS holdup tank recirculation pump discharge to the transfer canal suction/discharge piping. This is a normally isolated line that is an additional source of makeup water to the pools/transfer canal. The rate of addition is approximately 300 gpm. A normally closed valve is used to isolate this connection.

The CVCS holdup tank recirculation pump can take suction off any of the three CVCS holdup tanks. However, by procedure, the CVCS holdup tank recirculation pump is only allowed to be lined up to one holdup tank at a time. Manual valve manipulations are required to switch the pump suction to another tank. Each of the CVCS holdup tanks has a capacity of approximately 67,000 gallons and can be at a boron concentration from 0 ppm up to 3500 ppm. This connection is also a source of makeup water in case of a loss of spent fuel pool inventory event.

The final connection between the spent fuel pool and the CVCS is from the CVCS monitor tanks through a line that has three isolation valves. Two of these valves are

normally closed valves. The third valve is a normally open valve. This path can supply approximately 80 gpm and is a source of makeup water in case of a spent fuel pool loss of inventory. The three tanks are 10,000 gallons each and may contain non-borated water.

2.5.2 Reactor Water Makeup

The reactor water makeup system connects to the spent fuel pool cooling system directly at the outlet of the 121 spent fuel pool heat exchanger and indirectly through the boric acid blender (Section 2.5.1). Using the direct connection, the contents of the reactor makeup water tanks can be transferred via the reactor water makeup pumps directly to the spent fuel pool cooling system. The direct connection is normally isolated from the reactor water makeup system by a closed manual valve. The direct connection is used as the normal water supply to the spent fuel pool and is a source of makeup water in case of a loss of spent fuel pool inventory.

The reactor water makeup system consists of two reactor water makeup tanks and two reactor water makeup pumps for each unit. During normal operation, one reactor water makeup tank for each unit and its associated makeup pump are supplying reactor makeup water. The tanks are normally isolated from each other. Reactor makeup water can be supplied to the spent fuel pool cooling system from the tanks and pumps associated with either unit. However, the normal system lineup would provide spent fuel pool makeup from the Unit 1 tanks and pumps. The four reactor water makeup tanks each contain approximately 42,000 gallons of non-borated reactor grade water. The direct connection from the reactor water makeup pumps to the spent fuel pool cooling system can provide approximately 80 gpm of non-borated water to the spent fuel pool.

2.5.3 Demineralized Water System

The demineralized water system connects directly to the spent fuel pool cooling system at the purification loop demineralizer through a line that is isolated by a normally closed manual valve. The connection is normally used to sluice and refill the demineralizer during a resin changeout. The demineralized water system is normally supplied and pressurized by the reactor water makeup system. If the reactor water makeup system is supplying the demineralized water system, this connection can supply approximately 80 gpm of non-borated water to the outlet of the demineralizer.

If the reactor water makeup system is unavailable, the demineralized water system would be supplied and pressurized by the water treatment system. The water treatment system operating pressure is lower than the spent fuel pool cooling system operating pressure. Under those conditions the demineralized water system would be incapable of transferring water to the spent fuel pool cooling system.

There are also five demineralized water hose stations in the vicinity of the pools. Each of these stations can supply approximately 20 gpm of non-borated water. Only one of those stations is located directly next to the spent fuel pool and only that station is considered a possible dilution source for the spent fuel pool. That hose station is also a source of water in the case of a loss spent fuel pool inventory.

2.5.4 Component Cooling

Component cooling water is the cooling medium for the spent fuel pool cooling system heat exchangers. There is no direct connection between the component cooling system and the spent fuel pool cooling system. If however, a leak were to develop in a heat exchanger that is in service, the connection would be made. In case of a leak the spent fuel pool water would be expected to leak into the component

cooling system since the spent fuel pool cooling system normally operates at a slightly higher pressure than the component cooling system. However, since the operating pressures of the two systems are very close, it is feasible for a spent fuel pool cooling system heat exchanger tube leak to result in non-borated component cooling system water leakage into the spent fuel pool cooling system.

It would be expected that the flow rate of any leakage of component cooling water into the spent fuel pool cooling system would be very low due to the small difference in operating pressures between the two systems. Even if there was significant leakage from the component cooling system to the spent fuel pool, the impact on the spent fuel pool boron concentration would be minimal because the component cooling system contains a limited amount of water. Any loss of water from the component cooling system surge tank would be automatically replaced which could increase the amount of water available to dilute the pool. However, alarms and control room indications would alert the control room operators to any significant loss of water from the component cooling system.

If the alarms which would alert the control room operators of a component cooling system leak were to fail and leakage from the component cooling water system to the spent fuel pool cooling system were to continue undetected, the component cooling water surge tank would be periodically refilled with water from the reactor water makeup system. Since the component cooling surge tank would be refilled from the reactor makeup system, this scenario would be bounded by the reactor water makeup system dilution event discussed in Section 3.2.3.

Because of the limited amount of water available from the component cooling water system, and the mechanisms available to operators to help identify such leakage, a spent fuel pool heat exchanger leak cannot result in any significant dilution of the spent fuel pool and is not considered further in this analysis.

2.5.5 Aerated Waste

The aerated waste system connects directly to the spent fuel pool cooling system and skimmer system at five locations. The five locations are at the spent fuel pool heat exchanger tube bundle relief valves, the demineralizer drain and the skimmer system strainer and filter. The two heat exchanger lines discharge through a relief valve. The skimmer strainer and filter lines and the relief discharge line then combine into a line which flows through a check valve and then to 121 sump tank. Back flow through this path is not considered credible. There are two demineralizer connections that combine into a single line that is directed to 121 sump tank. Each connection has a normally closed valve to isolate it. The backflow of water into the spent fuel pool cooling system through this path is also considered not credible because the situation would cause water to back up through floor drains in a number of locations before getting into the spent fuel pool cooling system.

2.5.6 Resin Flush Line/Resin Fill Connection

The spent fuel pool cooling demineralizer has two additional connections not already discussed. The first is a resin flush line that is connected through a normally closed manual valve to a spent resin header which in turn connects to the 121 spent resin tank. The second is a resin fill line that is a flanged connection only opened when adding new resin to the demineralizer. Since neither of these paths can provide a significant dilution rate, they are not considered further in this analysis.

2.5.7 Fire Protection System

In the case of a loss of spent fuel pool inventory, the two local fire hose stations are potential makeup sources. Each of these stations is capable of providing 95 gpm of

non-borated water under normal conditions. Any planned addition of fire system water to the spent fuel pool would be under the control of an approved procedure and the effect of the addition of the non-borated water from the fire system on the spent fuel pool boron concentration would be addressed.

There are four fire protection hose stations and three supply lines for roof hose stations outside the spent fuel pool enclosure, but in the general area of the spent fuel pool. If any of these lines were to break, a significant amount of water would, if not isolated by operator action, be released into the area outside the spent fuel enclosure, some of which would flow under the doors into the spent fuel pool enclosure. The fire protection system contains instrumentation which would alarm in the control room should this type of flow develop in the fire protection system.

2.5.8 Reverse Osmosis System

In addition to the permanently installed spent fuel pool cleanup system there is a portable skid-mounted reverse osmosis system that is used to remove silica from the refueling water storage tank and can be used for the spent fuel pool as well. The unit forms a separate single loop which would take suction from the spent fuel pool cooling system or directly from the spent fuel pool, passes the water by the reverse osmosis membrane and then returns it to the cooling loop or spent fuel pool. The system operates at approximately 15 gpm. Along with the removal of the silica the system will remove some amount of boron and thus will require special administrative controls when placed in service.

For the purposes of this dilution analysis, it will be assumed that the reverse osmosis system removes all of the boron from the spent fuel pool water that passes through the system. As a result, the reverse osmosis system will be considered a 15 gpm source of non-borated water to the spent fuel pool. However, unlike the dilution

sources discussed above, dilution of the spent fuel pool resulting from operation of the reverse osmosis system will not result in an increase in the spent fuel pool level.

2.5.9 Dilution Source and Flow Rate Summary

Based on the evaluation of potential spent fuel pool dilution sources summarized above, the following dilution sources where determined to be capable of providing a significant amount of non-borated water to the spent fuel pool. The potential for these sources to dilute the spent fuel pool boron concentration down to the design basis boron concentration (750 ppm) will be evaluated in Section 3.0.

SOURCE	APPROXIMATE FLOW RATE (GPM)
CVCS Holdup Tank	
- Connection to SFP Transfer Canal	300
CVCS Monitor Tank	
- Connection to SFP Demineralizer	80
Reactor Makeup Tank	
- CVCS Blender	80[1]
- Direct Connection to SFP Hx Outlet	80
- Demineralized Water System to Spent Fuel Pool Cleanup System	80
- SFP Enclosure Hose Station	20
Reverse Osmosis System	15
Fire Protection Supply Lines	Indirect

[1] Flow from reactor water makeup system, no blended flow.

2.6 Boration Sources

The normal source of borated water to the spent fuel pool is through the blender in the CVCS system. An alternate source of borated water to the spent fuel pool is from the RWST. It is also possible to borate the spent fuel pool by the addition of dry boric acid directly to the spent fuel pool water.

2.6.1 Chemical and Volume Control System

The Chemical and Volume Control System (CVCS) is the normal borated makeup source for the spent fuel pool. The CVCS blender is connected to the spent fuel pool cooling system by a two inch line. This connection is used to supply water at a specific boron concentration to the pools. Concentrated boric acid is supplied to the CVCS blender from boric acid tanks via the boric acid transfer pumps. Reactor makeup water is supplied to the CVCS blender from the reactor makeup water tanks via the reactor makeup pumps. Flow controllers are used to control the boric acid and demineralized water flow to the blender and to establish the desired boron concentration in the water being sent to the spent fuel pool. The rate of addition through this connection is approximately 100 gpm when providing blended flow. The supply from the blender to the spent fuel pool cooling system can have a boron concentration of anywhere from 0 to 21,000 ppm depending on the control setting for the blender.

2.6.2 Refueling Water Storage Tank

Both the Unit 1 and Unit 2 refueling water storage tanks connect to the spent fuel pool through separate inlet and outlet lines. These connections are normally used to purify the RWST water when the purification loop is isolated from the spent fuel pool cooling system. If necessary, these connections can each supply approximately 80

gpm of borated water to the spent fuel pool via the reactor water purification pumps to the inlet to the spent fuel pool cooling system purification loop. The RWSTs are required by Technical Specifications to be kept at a minimum boron concentration of 2500 ppm.

2.6.3 Direct Addition of Boric Acid

If necessary, the boron concentration of the spent fuel pool can be increased by emptying bags of dry boric acid directly into the spent fuel pool. The dry boric acid will dissolve into the spent fuel pool water and will be mixed throughout the pool by the spent fuel pool cooling system flow and by the thermal convection created by the spent fuel decay heat.

2.7 Spent Fuel Pool Instrumentation

Instrumentation is available to monitor spent fuel pool water level and temperature, and the radiation levels in the spent fuel pool enclosure. Additional instrumentation is provided to monitor the pressure, flow and temperature of the spent fuel pool cooling and cleanup system.

The instrumentation provided to monitor the temperature of the water in the spent fuel pool is locally indicated as well as annunciated in the control room. The water level instrumentation alarms, high and low level, are annunciated in the control room. Both the large and small spent fuel pools have separate temperature and level indication. The instrumentation which monitors radiation levels in the spent fuel pool enclosure, provides high radiation alarms locally in the spent fuel pool enclosure and in the control room.

A change of one foot in spent fuel pool level with the small pool, large pool and

transfer canal connected requires approximately 12,000 gallons of water. If the pool level was raised from the low level alarm point to the high level alarm a dilution of approximately 14,000 gallons could occur before an alarm would be received in the control room. If the spent fuel pool boron concentration were at 1800 ppm initially, such a dilution would only result in a reduction of the pool boron concentration of approximately 63 ppm.

2.8 Administrative Controls

The following administrative controls are in place to control the spent fuel pool boron concentration and water inventory:

1. Procedures are available to aid in the identification and termination of dilution events.

2. The procedures for loss of inventory (other than evaporation) specify that borated makeup sources be used as makeup sources. The procedures specify that non-borated sources only be used as a last resort.

3. In accordance with procedures, plant personnel perform rounds in the spent fuel pool enclosure once every twelve hours. The personnel making rounds to the spent fuel pool are trained to be aware of the change in the status of the spent fuel pool. They are instructed to check the temperature and level in the pool and conditions around the pool during plant rounds.

4. Administrative controls are placed on some of the potential dilution paths.

5. The proposed Technical Specifications associated with the use of soluble boron credit will require the spent fuel pool boron concentration to be verified every seven days.

Prior to implementation of the License Amendment allowing credit for soluble boron in the spent fuel pool criticality analysis, current administrative controls on the spent fuel pool boron concentration and water inventory will be evaluated and procedures will be

upgraded as necessary to ensure that the boron concentration is formally controlled during both normal and accident situations. The procedures will ensure that the proper provisions, precautions and instructions will be in place to control the pool boron concentration and water inventory.

2.9 Piping

The piping in the vicinity of the spent fuel pool which could result in a dilution of the spent fuel pool if they were to fail is limited. The only piping located inside the spent fuel pool enclosure is a 3/4 inch demineralized water line. If that were to break the flow would exceed the normal 20 gpm flow rate for the station, but would be limited to the 80 gpm flow available from the reactor water makeup system. As such, any dilution resulting from the failure of the line supplying the demineralized water hose station would be bounded by the reactor water makeup system dilution events discussed below.

Other demineralized water hose stations, fire hose stations and fire hose station supply lines are located in the vicinity of the spent fuel pool but are outside the spent fuel pool enclosure. The fire protection lines, if damaged, could provide a source of spent fuel pool dilution via flow under the spent fuel pool enclosure doors. However, as discussed in Section 3.2, the physical arrangement of the area surrounding the spent fuel pool enclosure would limit the amount of water which could flow into the spent fuel pool enclosure.

2.10 Loss of Offsite Power Impact

Of the dilution sources listed in Section 2.5.9, only the fire protection system is capable of providing non-borated water to the spent fuel pool during a loss of offsite power.

The spent fuel pool level instrumentation is powered from emergency diesel generator backed power supplies.

The loss of offsite power would affect the ability to respond to a dilution. Neither of the normal sources of borated water to the spent fuel pool would be available upon a loss of offsite power. Manual addition of dry boric acid to the pool could be used if it became necessary to increase the spent fuel pool boron concentration during a loss of offsite power.

Currently the spent fuel pool cooling pumps are not automatically restarted following a loss of offsite power and are supplied by power supplies backed by non-safeguards diesel generators. However, modifications are underway to upgrade the spent fuel pool cooling pump power supplies to power supplies backed by emergency diesel generators.

3.0 SPENT FUEL POOL DILUTION EVALUATION

3.1 Calculation of Boron Dilution Times and Volumes

For the purposes of evaluating spent fuel pool dilution times and volumes, the total pool volume available for dilution is conservatively assumed to be 395,000 gallons. This is the total combined volume of the small pool, large pool and transfer canal when they are filled to the elevation associated with the pool low level alarm. The normal configuration of the Prairie Island spent fuel pool is to have all of the gates removed and the small pool, large pool and transfer canal all open to each other. In this configuration, any dilution of one of the pools or the transfer canal is assumed to affect all three.

The small pool can be isolated from the transfer canal and the large pool. An evaluation of the small pool, conservatively assumed to contain approximately 91,000 gallons when filled to the elevation associated with the pool low level alarm, would result in shorter dilution times. However, with the small pool isolated the only significant dilution sources available to the small pool would be introduced to the small pool through the spent fuel pool cooling system which also supplies the large pool. With the small pool isolated, any dilution of either pool would be evenly mixed between the two pools by the spent fuel pool cooling system. Thus even with the small pool isolated, as long as it is assumed that the cooling system is supplying both the large and small pools, any potential dilution events should be evaluated using a total pool volume of 395,000 gallons. Further discussion of the dilution of the small pool when isolated is provided in Section 3.3 below.

The transfer canal can be isolated from the large and small pools. When isolated from the transfer canal, the large and small pools are conservatively assumed to contain approximately 285,000 gallons of water when filled to the elevation associated with the pool low level alarm. An evaluation of spent fuel pool dilution events with the pools in this configuration would result in shorter dilution times than if the large and small pools were connected to the transfer canal. The effect of this configuration on the dilution events is evaluated in Section 3.3.3.

For Prairie Island, the boron concentration currently maintained in the spent fuel pool is greater than 3000 ppm. Based on the Prairie Island criticality analysis (Reference 1), the soluble boron concentration required to maintain the spent fuel boron concentration at $k_{eff} \leq 0.95$, including uncertainties and burnup, with a 95% probability at a 95% confidence level (95/95) is 750 ppm.

For the purposes of the evaluating dilution times and volumes, the initial spent fuel pool boron concentration is assumed to be at the proposed Technical Specification

limit of 1800 ppm. The evaluations are based on the spent fuel pool boron concentration being diluted from 1800 ppm to 750 ppm. To dilute the combined pool volume of 395,000 gallons from 1800 ppm to 750 ppm would conservatively require 345,000 gallons of non-borated water.

This analysis assumes thorough mixing of all the non-borated water added to the spent fuel pool. It is unlikely, with cooling flow and convection from the spent fuel decay heat, that thorough mixing would not occur. However, if mixing was not adequate, it would be conceivable that a localized pocket of non-borated water could form somewhere in the spent fuel pool. This possibility is addressed by the calculation in Reference 1 which shows that the spent fuel rack K_{eff} will be less than 1.0 on a 95/95 basis with the spent fuel pool filled with non-borated water. Thus, even if a pocket of non-borated water formed in the spent fuel pool, K_{eff} would not be expected to exceed 1.0 anywhere in the pool.

The time to dilute depends on the initial volume of the pool and the postulated rate of dilution. The dilution volumes and times for the dilution scenarios discussed in Sections 3.2 and 3.3 are calculated based on the following equation:

$$t_{end} = \ln (C_o / C_{end}) V/Q \qquad \text{(Equation 1)}$$

Where:

C_o = the boron concentration of the pool volume at the beginning of the event (1800 ppm)

C_{end} = the boron endpoint concentration (750 ppm)

Q = dilution rate (gallons of water/minute)

V = volume (gallons) of spent fuel pool.

3.2 Evaluation of Boron Dilution Events

The potential spent fuel pool dilution events that could occur at Prairie Island are evaluated below:

3.2.1 Dilution From CVCS Holdup Tanks

The contents of a CVCS holdup tank can be transferred via the CVCS holdup tank recirculation pump directly to spent fuel pool transfer canal suction/discharge piping. The flow path to the transfer canal is through a line that is isolated by one normally closed valve. This connection is a designated source of makeup water in a loss of spent fuel pool inventory event. Because the flow from the holdup tank recirculation pump discharges only into the transfer canal, the dilution source from the CVCS holdup tanks would not affect the small pool if it were isolated from the large pool and the transfer canal. Each of the three CVCS holdup tanks have a capacity of approximately 67,000 gallons. The water in the tanks can have a boron concentration from 0 ppm to 3500 ppm. Any amount of boron in the CVCS holdup tank water would reduce the dilution of spent fuel pool resulting from the transfer of CVCS holdup tank water to the spent fuel pool. The combined contents of the three CVCS holdup tanks (approximately 200,000 gallons) is far less than the amount of water necessary to dilute the spent fuel pool from 1800 ppm to 750 ppm.

The CVCS holdup tank recirculation pump can take suction off any one of the three CVCS holdup tanks with a flow rate of approximately 300 gpm. The CVCS holdup tank recirculation pump is only allowed to be lined up to one holdup tank at a time. Manual valve manipulations are required to switch the pump suction to another tank. Thus, it is assumed for the purposes of this evaluation that only the contents of one CVCS holdup tank is available for a spent fuel pool dilution event. Because the 67,000 gallons of water contained in one CVCS holdup tank is far less than the

amount of water necessary to dilute the spent fuel pool from 1800 ppm to 750 ppm, and because it is very unlikely that more than one CVCS holdup tank could be transferred to the spent fuel pool during an unplanned dilution event, the CVCS holdup tanks are not considered a credible dilution source for the purposes of this analysis.

3.2.2 Dilution From CVCS Monitor Tanks

The contents of the three CVCS monitor tanks can be transferred via the monitor tank pumps through a special lineup to the spent fuel pool cooling system. The flow path from the CVCS monitor tank pump discharge to the spent fuel pool cooling system is through a line that has three isolation valves. Two of these valves are normally closed. The third valve is a normally open valve. This path can supply 80 gpm to the spent fuel pool cooling system and is a makeup supply in case of a spent fuel pool loss of inventory. The three CVCS monitor tanks are 10,000 gallons each and may contain non-borated water.

Because the 30,000 gallons of water contained in the CVCS monitor tanks is far less than the amount of water necessary to dilute the spent fuel pool from 1800 ppm to 750 ppm, the CVCS monitor tanks are not considered a credible dilution source for the purposes of this analysis.

3.2.3 Dilution From Reactor Water Makeup Tanks

The contents of the reactor makeup water tanks can be transferred via the reactor water makeup pumps directly through a line to the spent fuel pool cooling system at the outlet of the 121 spent fuel pool heat exchanger. This connection is normally isolated from the reactor water makeup system by a closed manual valve. It is used as the normal makeup supply to the spent fuel pool and is a source of makeup water in case of a loss of spent fuel pool inventory event.

The reactor water makeup system consists of two reactor water makeup tanks and two reactor water makeup pumps for each unit. Reactor makeup water can be supplied to the spent fuel pool cooling system from the tanks and pumps associated with either unit. The four reactor water makeup tanks contain approximately 42,000 gallons of non-borated reactor grade water each. The direct connection from the reactor water makeup pumps to the spent fuel pool cooling system can provide approximately 80 gpm of non-borated water to the spent fuel pool.

The normal reactor water makeup system configuration would limit the amount of reactor makeup water available to the spent fuel pool during an inadvertent dilution event. During normal operation, one reactor water makeup tank for each unit and its associated makeup pump are supplying the reactor makeup and demineralized water systems. To prevent one tank from contaminating the others, the tanks are normally isolated from each other. If all four reactor water makeup tanks were to be transferred to the spent fuel pool, the lineup for each unit would have to be manually switched to the second tank after the first tank was drained.

While the normal configuration of the reactor makeup water system would limit the amount of water available to dilute the spent fuel pool to the contents of one reactor makeup tank (42,000 gallons), the contents of the in service reactor water makeup tank can be manually replenished from the water treatment system. Each water treatment train is capable of generating approximately 250,000 gallons of demineralized water before the ion exchangers reach exhaustion and the train is automatically shutdown. It is possible to operate the two water treatment trains in parallel. In that configuration the water treatment system could provide approximately 500,000 gallons of demineralized water to the reactor makeup system before the water treatment system would automatically shutdown. Therefore, by repeatedly replenishing the inservice reactor makeup water tank from the water treatment

system, the reactor water makeup system is capable of providing more than the 345,000 gallons of water required to dilute the spent fuel pool from 1800 ppm to 750 ppm.

Assuming the inservice reactor water makeup tank is replenished as necessary, the 80 gpm flow of water from the reactor water makeup system to the spent fuel pool cooling system would take over 72 hours to reduce the pool boron concentration from 1800 ppm to 750 ppm.

3.2.4 Dilution From CVCS Blender

Makeup to the spent fuel pool (reactor makeup water blended with concentrated boric acid) may be provided via the Unit 1 CVCS blender. This manual connection is used to supply water at a specific boron concentration from the CVCS blender to the spent fuel pool cooling system. The connection is on the down stream side of the boric acid blender and is isolated by two manual valves. One valve is a normally closed valve that isolates a header that supplies the spent fuel pool cooling system, the refueling water storage tank (RWST) and CVCS holdup tanks through a check valve. The other valve is a normally closed valve that isolates the spent fuel pool cooling system from the CVCS. Thus, there are two normally closed manual valves that must be opened and left open to allow a dilution event via the CVCS blender.

When delivering blended flow, this connection can deliver a flow rate of approximately 100 gpm to the spent fuel pool. If only non-borated reactor makeup water is being supplied to the blender, the flow to the spent fuel pool would be limited by the capability of the reactor makeup water system to approximately 80 gpm.

Assuming the CVCS blender controls were set to provide unlimited non-borated water, the two valves connecting the blender to the spent fuel pool cooling system were

inadvertently left open, and the inservice reactor water makeup tank was repeatedly replenished, the 80 gpm flow from the CVCS blender to the spent fuel pool cooling system would take over 72 hours to reduce the pool boron concentration from 1800 ppm to 750 ppm.

This scenario assumes that the water supplied by the CVCS blender is non-borated. If the blender controls are set to provide borated water, the spent fuel pool dilution rate would be reduced. The controls which supply the non-borated water to the blender utilize an integrator to limit the amount of water that can be supplied to the blender. If the blender controls were set to provide only a limited amount of water, the dilution of the spent fuel pool would be reduced.

3.2.5 Dilution From Demineralized Water System

Non-borated water can be provided from the demineralized water system directly to the spent fuel pool cooling system at the purification loop demineralizer through a line that is isolated by a normally closed manual valve. The connection is normally used to sluice and refill the demineralizer during a resin changeout. If valves are misaligned during that operation, it is possible that non-borated water could be inadvertently delivered to the spent fuel pool.

The demineralized water distribution system is normally supplied with water by the reactor water makeup system. When the reactor water makeup system is supplying the demineralized water system, this connection can supply approximately 80 gpm of non-borated water to the outlet of the spent fuel pool demineralizer and thus to the spent fuel pool.

If the reactor water makeup system is unavailable, the demineralized water system would be supplied by the water treatment system. The water treatment system

operating pressure is lower than the spent fuel pool cooling system operating pressure. Under those conditions the demineralized water system would be incapable of transferring water to the spent fuel pool cooling system.

Assuming the reactor water makeup system is supplying the demineralized water system, the valve connecting the demineralized water system to the spent fuel purification system were inadvertently left open, and the inservice reactor water makeup tank was repeatedly replenished, the 80 gpm flow from the demineralized water system to the spent fuel purification system would take over 72 hours to reduce the pool boron concentration from 1800 ppm to 750 ppm.

There are also five demineralized water hose stations in the vicinity of the pools. Each of these stations can supply approximately 20 gpm of non-borated water. Only one of these stations is located directly next to the spent fuel pool and only that station is considered a dilution source for the spent fuel pool. If demineralized water from the reactor water makeup system were transferred to the spent fuel pool via the demineralized water hose station in the spent fuel pool enclosure, the 20 gpm flow of non-borated water to the spent fuel pool would take over 12 days to reduce the pool boron concentration from 1800 ppm to 750 ppm. For this dilution to occur, the inservice reactor water makeup tank would have to be repeatedly replenished.

Because a spent fuel pool dilution related to the 20 gpm flow from the demineralized water hose station in the spent fuel pool enclosure would be bounded by the 80 gpm reactor water makeup system dilution events discussed above, the 20 gpm dilution event is not considered further in this analysis.

3.2.6 Dilution Resulting From Seismic Events or Random Pipe Breaks

A seismic event could cause piping ruptures in the vicinity of the spent fuel pool in piping that is not seismically qualified. The only piping within the immediate vicinity of the spent fuel pool that could result in dilution of the spent fuel pool if it ruptures during a seismic event is the 3/4" demineralized water hose station discussed in Section 3.2.5.

For a seismic event at Prairie Island, if offsite power is available, rupture of the 3/4" demineralized water hose station located inside the spent fuel pool enclosure would result in flow exceeding the normal 20 gpm flow rate for the station, but would be limited to the 80 gpm flow available from the reactor water makeup system. As such, any dilution resulting from the failure of the line supplying the demineralized water hose station would be bounded by the reactor water makeup system dilution events discussed above.

If offsite power is not available, the reactor water makeup and demineralized water systems would not operate and thus there would be no dilution source. The effects of a spent fuel pool dilution related to the normal flow from the demineralized water hose station in the spent fuel pool enclosure is discussed in Section 3.2.5.

In the event of a break in one of the fire protection hose station supply lines which are outside the spent fuel pool enclosure but in the general area surrounding the spent fuel pool, water could reach the spent fuel pool by flowing under the doors of the spent fuel pool enclosure. A break in a fire protection hose station supply line could result in significant flooding in the area surrounding the spent fuel pool enclosure. However, in that area there are two open stairwells, two floor drains and numerous small opening in the floor through which this water would drain to lower elevations of the auxiliary building. For the purposes of this analysis, it is conservatively assumed

that a fire protection hose station line break floods the entire area, including the inside of the spent fuel pool enclosure to a depth of six inches. This is conservative because of the number of openings to the lower floors and because there is a drop area opening of greater than 500 ft^2 located next to the spent fuel pool enclosure. This drop area is surrounded by a four inch toe plate which would limit flow to the lower elevations of the auxiliary building until the water level exceeded four inches. Once the water level reached four inches, the drop area would be capable of draining the full flow of any fire protection hose station supply line break.

Once the water depth was equalized at six inches inside and outside the spent fuel pool enclosure, the driving head to force additional water into the enclosure would be significantly reduced. At that point most of the flow from the pipe break would bypass the spent fuel pool enclosure, taking the path of least resistance around the enclosure to the drop area opening. Some flow would pass through the spent fuel pool enclosure to the drop area opening, but that flow would be restricted by the limited openings under the enclosure doors.

The total amount of water added to the spent fuel pool enclosure to raise the water level to six inches above the floor would be approximately 95,000 gallons assuming the spent fuel pool was initially at a level equivalent to the low level alarm setpoint. This is much less than the 345,000 gallons required to dilute the spent fuel pool from 1800 ppm to 750 ppm. While a limited amount of flow through the enclosure would continue until the line break were isolated, a fire protection system line break of this magnitude would be readily detected in the control room and break flow would be terminated long before enough water could enter the spent fuel pool enclosure to reduce the pool boron concentration to 750 ppm.

Because of the limited flow into the spent fuel pool enclosure, and because a fire protection hose station supply line break would be terminated long before the spent

fuel pool boron concentration would be reduced to 750 ppm, this event is not considered a credible event and is given no further consideration in this analysis.

3.2.7 Dilution From Reverse Osmosis System

Once the License Amendment Request allowing credit for soluble boron in the spent fuel rack criticality analysis is approved, no credit will be taken for the Boraflex neutron absorber panels in the spent fuel racks. At that point it will be desirable to remove the silica from the spent fuel pool water to facilitate compliance with the EPRI primary water chemistry guidance's following a refueling outage. It is anticipated that the reverse osmosis system described in Section 2.5.8 would be used to remove the silica from the spent fuel pool water.

Water would be taken from the spent fuel pool cooling system or directly from the spent fuel pool, would be passed by the reverse osmosis membrane where the silica would be removed, and then would be returned to the spent fuel pool cooling loop or the spent fuel pool. Along with the removal of the silica, the system will remove some amount of boron from the water passing through it. As a consequence, the discharge returning to the spent fuel pool would have a lower concentration of boron than the suction coming from the spent fuel pool. The reverse osmosis system operates at approximately 15 gpm.

During the setup of the reverse osmosis system samples would be taken from the output of the system to determine the rate of silica and boron removal. Using that information, administrative controls would be put in place to ensure boron levels in the spent fuel pool would remain above the required value during reverse osmosis operations. Typically, over 90% of the boron contained in the spent fuel pool water passing through the reverse osmosis system will be returned to the spent fuel pool.

For the purposes of this dilution analysis, it will be assumed that the reverse osmosis system removes all of the boron from the spent fuel pool water that passes through the system. As a result, the reverse osmosis system will be considered a 15 gpm source of non-borated water to the spent fuel pool. However, unlike the dilution sources discussed above, dilution of the spent fuel pool resulting from operation of the reverse osmosis system will not result in an increase in the spent fuel pool level. Assuming the reverse osmosis system operates as a 15 gpm dilution source, it would take the system nearly 16 days to reduce the spent fuel pool boron concentration from 1800 ppm to 750 ppm. During that 16 day period the spent fuel pool boron concentration will be sampled once every seven days per the proposed Technical Specification changes. That sampling would identify any reduction in the spent fuel boron concentration well before the 750 ppm limit would be reached.

A dilution of the spent fuel pool from 1800 ppm to 750 ppm resulting from the use of the reverse osmosis system is not considered credible due to the length of time that would be required to dilute the spent fuel pool to that concentration, in combination with the boron sampling required by the proposed Technical Specifications and the special administrative controls that would be in place during the use of the reverse osmosis system. Because the dilution of the spent fuel pool from 1800 ppm to 750 ppm by the reverse osmosis system is not considered a credible event, it is given no further consideration in this analysis.

3.2.8 Dilution From Spent Fuel Pool Demineralizer

When the spent fuel pool demineralizer is first placed in service after being recharged with fresh resin it can initially remove boron from the water passing through it. In the worst case, assuming pure anion resin, the demineralizer could remove a maximum of 10 ppm of boron from the spent fuel pool water before the resin would become saturated. The demineralizer normally utilizes a mixed bed of anion and cation resin

which would remove less boron before saturating. Because of the small amount of boron removed by the demineralizer, it is not considered a credible dilution source for the purposes of this evaluation.

3.3 Evaluation of Infrequent Spent Fuel Pool Configurations

3.3.1 Dilution of Isolated Small Pool

The only way that the volume of an isolated small pool could be diluted independent of the large pool is if the spent fuel pool cooling system was isolated from the large pool, but was still supplying the small pool. The spent fuel pool has never been in this configuration. It is unlikely that the pool would ever be placed in this configuration. However, it is evaluated here in the interest of completeness. If this configuration were used, it would be of limited duration and would involve special procedures, controls and monitoring. It is unlikely that any significant dilution of the small pool under these conditions could occur without detection.

It is assumed for this evaluation that the small pool is isolated from the large pool and the transfer canal. In this configuration, the only significant dilution sources are the three 80 gpm sources to the spent fuel pool cooling system from the reactor makeup water system. Assuming the volume of the small pool is 91,000 gallons (pool at level associated with low limit alarm) and that the inservice reactor water makeup tank is being repeatedly replenished, an 80 gpm dilution rate would take over 16 hours and approximately 79,000 gallons of non-borated water to reduce the small pool boron concentration from 1800 ppm to 750 ppm.

If flow from the demineralized water header could reach the small pool, the dilution resulting from the 20 gpm flow rate would be bounded by the flow from the 80 gpm sources. The 300 gpm flow rate from the CVCS holdup tank recirculation pump

would not be available to the small pool under these conditions because the small pool would be isolated from the transfer canal.

In order for a significant dilution of the small pool to take place undetected, both the large and small pool level alarms would have to fail. The large pool level alarm would provide valid indication of a small pool dilution because the small pool would flow over the gates into the large pool and the transfer canal. Even if both high level alarms fail, it is reasonable to expect that the significant increase in pool level and eventual pool overflow will be readily detected by plant operators in time to take mitigative actions. A pool overflow condition will result in flooding in the plant auxiliary building and numerous sump alarms. In addition, because the time required to reach a boron concentration of 750 ppm is greater than twelve hours, it can be assumed that the operator inspection of the spent fuel pool area that occurs once per twelve hours will detect the increase in the pool level even if the alarms fail and the flooding isn't detected elsewhere in the auxiliary building.

The spent fuel pool would not be placed in the configuration required to support this event, i.e., small pool isolated from large pool and transfer canal with cooling isolated to large pool, without extensive review and evaluation. Any evolution such as this would require the development of special procedures and controls to ensure the continued safe operation of the spent fuel pool. Those procedures and controls would be expected to include limits on how long the cooling to the large pool could be isolated and requirements for increased monitoring of the pool area and conditions. For these reasons this event is not considered credible and is not considered further in this analysis.

3.3.2 Dilution of Small Pool With Reduced Level

Whenever a TN-40 dry storage cask is lowered into or raised out of the cask loading area of the small pool, the small pool is isolated, the cooling to the small pool is isolated and the water level is lowered approximately ten feet. This condition only exists for a short period of time. The level and cooling are restored to normal during the cask loading or unloading operations.

The only possible dilution source available to the small pool when it is isolated with the cooling system isolated is a 20 gpm flow of demineralized water from the hose station inside the spent fuel pool enclosure. The small pool contains approximately 78,000 gallons of water when drained to lower or raise a cask. Using this 20 gpm dilution rate, it would take would take over 56 hours and approximately 68,000 gallons of non-borated water to reduce the small pool boron concentration to 750 ppm under these conditions.

Because of the special nature of this evolution, special procedures, controls and monitoring are in place during the period of time casks are raised and lowered. The possibility of any significant dilution of the small pool under these conditions is not credible due to the likelihood of detection, the limited time duration of this scenario and the special controls that would be in place for such a condition. Therefore, for the reasons just outlined, and because this configuration is only in place for a short period of time a few times a year, this dilution event is not considered further in this analysis.

Pool level is also lowered the same amount for the installation or removal of the fuel storage racks in the cask loading area. This is a less frequent event than cask raising or lowering, and is bounded by the above analysis.

3.3.3 Dilution with Transfer Canal Isolated

It is assumed for this evaluation that the transfer canal is isolated from the large and small pools. In this configuration, the only significant dilution sources are the three 80 gpm sources to the spent fuel pool cooling system from the reactor makeup water system. Assuming the volume of the large and small pools is 285,000 gallons (pools at level associated with low limit alarm) and that the inservice reactor water makeup tank is being repeatedly replenished, an 80 gpm dilution rate would take over 51 hours and approximately 250,000 gallons of non-borated water to reduce the large and small pool boron concentration from 1800 ppm to 750 ppm.

If flow from the demineralized water header could reach the large and small pools, the dilution resulting from the 20 gpm flow rate would be bounded by the flow from the 80 gpm sources. The 300 gpm flow rate from the CVCS holdup tank recirculation pump would not be available to the large and small pools under these conditions because the large and small pools would be isolated from the transfer canal.

In order for a significant dilution to go undetected in this configuration, both the large and small pool level alarms would have to fail. Even if both high level alarms fail, it is reasonable to expect that the significant increase in pool level and eventual pool overflow will be readily detected by plant operators in time to take mitigative actions. A pool overflow condition will result in flooding in the plant auxiliary building and numerous sump alarms. In addition, because the time required to reach a boron concentration of 750 ppm is greater than two days, it can be assumed that the operator inspection of the spent fuel pool area that occurs once per twelve hours will detect the increase in the pool level even if the alarms fail and the flooding isn't detected elsewhere in the auxiliary building.

Because this configuration is used infrequently, and because of the large volume of

water and length of time required to dilute the large and small pools from 1800 ppm to 750 ppm, this event is not considered credible and is not considered further in this analysis.

3.4 Summary of Dilution Events

The evaluation of spent fuel pool dilution events in Sections 3.2 and 3.3 eliminated from consideration all but three of the of the dilution scenarios evaluated. The three dilution scenarios remaining all involve the transfer of non-borated water from the reactor water makeup system to the spent fuel pool cooling or cleanup systems at a rate of approximately 80 gpm. The reactor water makeup system is capable of supplying the approximately 345,000 gallons of water necessary to dilute the spent fuel pool from 1800 ppm to 750 ppm if the inservice reactor water makeup tank is repeatedly replenished from the water treatment system. Based on the analysis in Section 3.2 any of these three scenarios would require greater than 72 hours for the spent fuel pool boron concentration to be reduced from 1800 ppm to 750 ppm.

However, for any one of these three scenarios to successfully result in the dilution of the spent fuel pool from 1800 ppm to 750 ppm, the addition of 345,000 gallons of water to the spent fuel pool over a period of three days would have to go unnoticed. The first indication of such an event would be high level alarms in the control room from the small and large pool level instrumentation. If the high level alarms fail, it is reasonable to expect that the significant increase in pool level and eventual pool overflow that would result from a pool dilution event will be readily detected by plant operators in time to take mitigative actions. A pool overflow condition would result in flooding in the plant auxiliary building and numerous sump alarms. In addition, because the time required to reach a boron concentration of 750 ppm from 1800 ppm is significantly longer than twelve hours, it can be assumed that the operator rounds through the spent fuel pool area that occur once per twelve hours

will detect the increase in the pool level even if the alarms fail and the flooding isn't detected.

In addition, for any one of these three dilution scenarios to successfully add 345,000 gallons of water to the spent fuel pool, plant operators would have to fail to question or investigate the continuous makeup of water to the reactor water makeup tank for the required 72 hour time period, and fail to recognize that the need for 345,000 gallons of makeup was unusual.

It should be noted that even if a spent fuel pool dilution flow rate as high as 450 gpm were assumed, a dilution from 1800 ppm to 750 ppm would still require the same amount of non-borated water (approximately 345,000 gallons) and would still take greater than 12 hours. Thus, even a spent fuel pool dilution at a significantly higher flow rate than assumed in Sections 3.2 and 3.3 would still be readily detected by alarms, flooding or operator rounds before the spent fuel pool boron concentration could reach 750 ppm.

4.0 CONCLUSIONS

A boron dilution analysis has been completed for the Prairie Island spent fuel pool. As a result of this spent fuel pool boron dilution analysis, it is concluded that an unplanned or inadvertent event which would result in the dilution of the spent fuel pool boron concentration from 1800 ppm to 750 ppm is not a credible event. This conclusion is based on the following:

1. In order to dilute the spent fuel pool to the design k_{eff} of 0.95, a substantial amount of water (nearly 350,000 gallons) is needed. It would take continued manual actions on the part of plant personnel over a long period of time to assure that enough water would be available to support such a dilution.

2. Since such a large water volume turnover is required, a spent fuel pool dilution event would be readily detected by plant personnel via alarms, flooding in the auxiliary building or by normal operator rounds through the spent fuel pool area.

3. Evaluations indicate that based on the flow rates of non-borated water normally available to the spent fuel pool, even when significantly higher flow rates are assumed, sufficient time is available to detect and respond to such an event.

It should be noted that this boron dilution evaluation was conducted by evaluating the time and water volumes required to dilute the spent fuel pool from 1800 ppm to 750 ppm. The 750 ppm end point was utilized to ensure that K_{eff} for the spent fuel racks would remain less than or equal to 0.95. As part of the criticality analysis for the Prairie Island Spent fuel racks (Reference 1), a calculation has been performed on a 95/95 basis to show that the spent fuel rack K_{eff} remains less than 1.0 with non-borated water in the pool. Thus, even if the spent fuel pool were diluted to zero ppm, which would take significantly more water than evaluated above, the racks would be expected to remain subcritical and the health and safety of the public would be assured.

5.0 REFERENCES

1. Northern States Power Prairie Island Units 1 and 2 Spent Fuel Rack Criticality Analysis Using Soluble Boron Credit, Westinghouse Commercial Nuclear Fuel Division, February 1997.

FIGURE 2-1

SPENT FUEL POOL RELATED SYSTEMS

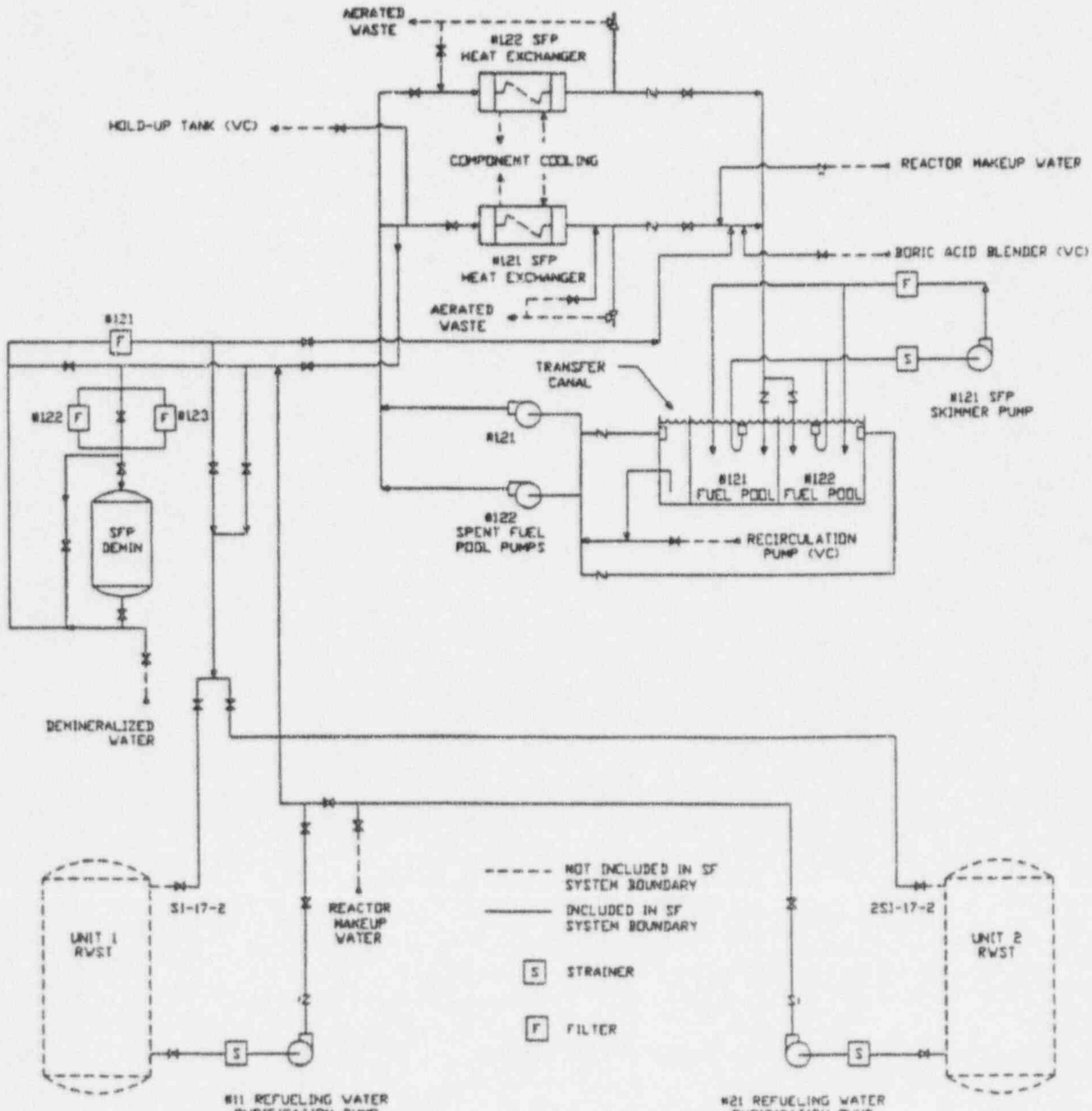

Exhibit E

Prairie Island Nuclear Generating Plant
February 21, 1997 Revision to
License Amendment Request Dated July 28, 1995

Northern States Power Prairie Island
Units 1 and 2 Spent Fuel Rack
Criticality Analysis Using
Soluble Boron Credit

February 1997