9.2 WATER SYSTEMS

9.2.1 SERVICE WATER SYSTEM

9.2.1.1 Design Bases

The Service Water System (SWS) has no safety related function and is designed to remove heat from heat exchangers in the turbine, reactor, and radwaste buildings and to transfer this heat to the cooling towers where it is dissipated.

The SWS is designed to operate during normal plant operation and plant shutdown with offsite power available. The system will not operate on loss of offsite power.

9.2.1.2 System Description

The SWS is a single loop, which includes three 50 percent capacity, horizontal, centrifugal, single stage pumps, located in the circulating water pump house, operating in parallel (Normally, two pumps are in service with the third on automatic standby. The system can be operated with one pump in service during plant shutdowns when heat loads are low) to circulate cool side cooling tower water through the heat exchangers listed in Table 9.2-1 and to discharge it back to the tower by way of the circulating water piping. In most cases the service water flows through the heat exchangers' tubes. The system is shown schematically on Dwgs. M-109, Sh. 1, M-109, Sh. 2, M-109, Sh. 3, M-110, Sh. 1 and M-2110, Sh. 1.

The water source and heat sink for the service water system is the cooling tower. The cooling tower dissipates a maximum design heat load of approximately 1.88×10^8 Btu/hr of heat from the service water system. The system is designed for a maximum total flow of 26,617 gpm with a corresponding discharge pressure of approximately 126 psi. The system piping design pressures vary throughout the system. The piping design pressures were established based on the evaluation and location of the piping in the system. Each of the two generating units is provided with a separate SWS and cooling tower, although the two systems are interconnected so that equipment common to both units can be supplied from either SWS.

The system's heat exchangers are sized to operate with 95°F service water at the inlets. For accessible areas the pipe is carbon steel with a corrosion allowance of 0.1875 in., while for inaccessible areas 90/10 copper nickel piping is used.

The temperature of fluids in the respective heat exchangers are regulated by either recirculation of the service water or flow control of the service water.

Recirculation

In this type of regulation the inlet temperature of the service water is controlled by recirculating some of the warm service water discharging from the respective heat exchanger back into the cool service water entering the heat exchanger. The amount of warm service water recirculated is controlled by a valve that is regulated by a temperature controller in the service water discharge from the heat exchanger.

This type of temperature regulation is used for the following:

a) Control structure chillers

b) Radwaste building chillers

c) Turbine building chillers

d) Reactor building chillers.

<u>Flow Control</u>

In this type of regulation the temperature of the fluid being cooled is regulated by adjusting the flow of service water through the respective heat exchanger. This is done by a control valve located in the service water discharge line from the heat exchanger, which is regulated by a temperature controller that senses the temperature of the cooled fluid.

This type of temperature regulation is used for the following:

a) Generator hydrogen coolers

b) Turbine Building Closed Cooling Water (TBCCW) heat exchangers

c) Reactor Building Closed Cooling Water (RBCCW) heat exchangers

d) Gaseous Radwaste Recombiner Closed Cooling Water (GRRCCW) heat exchangers

e) Main turbine lube oil coolers

f) Reactor feed pump turbine lube oil coolers

g) Alterrex air coolers

h) Reactor recirculation pump M-G set hydraulic fluid coolers

The balance of the heat exchangers as listed in Table 9.2-1 have the service water flow adjusted manually to obtain the required fluid temperature.

A back pressure regulator installed in the service water return header from the fuel pool heat exchangers maintains a positive pressure differential between the tube and shell sides of the heat exchangers to prevent possible radioactive contamination of the SWS.

In the case of loss of offsite power, the cooling of the RBCCW heat exchangers and TBCCW heat exchangers can be remote manually transferred from the SWS to the Emergency Service Water System (ESWS) as permitted in system operating procedures. However, since the heat exchangers are designed for non-essential service, the transfer valves are designed to close on failure of the solenoid valves which control them, ensuring no loss of emergency service water.

A Chemical Addition System is located in the basement of the Circulating Water Pumphouse and dispenses water treatment chemicals such as corrosion inhibitors, dispersants, scale inhibitors and biocides directly into the Service Water System pump suction headers of both

units. The Chemical Injection System is designed as an independent system (except for required control logic tie-in) so that its failure would not render the SWS inoperable. The system includes pump skids, storage tanks, control cabinets, and a fill station outside of the Circulating Water Pumphouse.

Internal corrosion is being monitored through periodic non-destructive examination of in-plant piping, including ultrasonic measurement of wall thickness and radiography, at selected locations. This is supplemented by visual inspection of selected piping and components when opened for maintenance, and destructive examination of piping removed during maintenance or modification as appropriate. The inspection program is described in PPL Specification H-1019, Inspection Program for Piping Corrosion and Degradation.

Segments of service water pipe are externally wrapped with a composite carbon fiber wrap system due to degradation of the original pipe material. The composite carbon fiber wrap system is qualified to ANSI B31.1 and PCC-2 requirements and constitutes the pressure boundary.

9.2.1.3 Safety Evaluation

The SWS operation has no safety related function and failure of the system will not compromise any safety related system or component or prevent a safe nuclear shutdown.

9.2.1.4 Tests and Inspections

The system is hydrostatically tested prior to startup and preoperationally tested in accordance with the requirements of Chapter 14. The standby pump will be tested and put into regular service periodically to ensure system integrity. Standby heat exchangers will be alternated into service on a regular basis.

9.2.1.5 Instrumentation Applications

The suction header of the service water pumps is provided with a pressure indicator and each pump has a pressure indicator on its discharge line. A temperature indicator is located on the common discharge header. The discharge header is monitored for low pressure. If either of the operating pumps fails, the standby pump will start automatically.

Each heat exchanger in the system, except the Containment ILRT Equipment and the Deaerator Seal Water Cooler, is provided with a pressure test connection or pressure indicator in both the inlet and outlet lines. A temperature indicator is also provided in the outlet lines.

Manually operated throttling valves have been provided downstream of the heat exchangers for initial design service water flow rates adjustment. Automatic temperature control valves have been provided wherever it is necessary to keep operating temperatures controlled within a specific range.

9.2.2 REACTOR BUILDING CLOSED COOLING WATER SYSTEM

9.2.2.1 Design Basis

The Reactor Building Closed Cooling Water (RBCCW) System has no safety related function and is a closed loop system that transfers heat from miscellaneous reactor auxiliary plant equipment to the service water system through the heat exchangers. The plant equipment serviced by the RBCCW system is located in the Reactor and Radwaste Buildings.

The RBCCW system is required to operate during normal operation and on loss of off-site power. In the event that the Reactor Building chillers are unavailable, the RBCCW system is designed to automatically furnish cooling water to the Reactor Building Chilled Water System for drywell cooling. The drywell coolers can also be manually switched to the RBCCW system.

9.2.2.2 System Description

The RBCCW system consists of two 100 percent capacity cooling water pumps, two 100 percent heat exchangers, one head tank, one chemical addition tank, associated valves, piping and controls as shown on Dwg. M-113, Sh. 1.

System containment penetrations and isolation valves are designed to Seismic Category I and ASME Code Section III, Class 2 requirements. The system piping located inside containment to and from the Reactor Recirculation Pump and Motor coolers is designed to ANSI B31.1 requirements. This piping is designed to withstand the SSE such that its failure or loss of function will not impair safety related systems located inside containment. The system piping which is located outside containment is designed to ANSI B31.1 requirements. All piping is carbon steel.

The RBCCW system provides cooling water to non-safety related equipment located in the Reactor and Radwaste Buildings which has the potential to carry radioactive fluids or which requires a clean water supply to minimize long term corrosion. The service water in the heat exchanger tube side is maintained by the service water pumps at a higher pressure than the closed loop system in the heat exchanger shell side. In the event of tube failure, the service water would leak into the closed loop system to preclude the possibility of radioactive release to the environment.

During normal operation, one cooling water pump and one heat exchanger are in service. The second pump is on automatic standby. A heat load of approximately 19.85×10^6 Btu/hr is transferred from the closed cooling water system to the service water system in the heat exchanger. During normal plant operation, the RBCCW system furnishes cooling water to the following components:

The following equipment is located in the Reactor Building:

1) Cleanup Non-Regenerative Heat Exchanger

2) Cleanup Recirculation Pump Coolers

3) Reactor Recirculation Pump Seal and Motor Oil Coolers

4) Reactor Building Sump Cooler

5) Sample Station Chillers and Coolers

6) Containment Instrument Gas Compressor Coolers

7) Process Sampling Cooler

The following equipment is located in the Radwaste Building:

1) Low Pressure Compressor and After Cooler

2) Off gas Precoolers

3) Off gas Refrigeration Condensers

The water is circulated throughout the closed loop by the pump, which is rated at 1100 gpm at 90 ft head. The capacity of cooling water required by each plant component is set by a manual throttling valve on the cooling water outlet of each unit.

The closed loop cooling water temperature leaving the RBCCW heat exchanger is automatically controlled by an air-operated flow control valve located on the service water side. Automatic control is carried out by a temperature indicating controller which maintains the closed cooling water outlet temperature at approximately 90°F. While there is no specified lower limit for operation there is an alarm set at 105°F to ensure cooling is being furnished to the above mentioned components.

Upon loss of off-site power without occurrence of a loss of coolant accident, the RBCCW heat exchangers can be manually switched from the service water (SW) system to the emergency service water system (ESW) as permitted by system operating procedures. The RBCCW pumps start automatically, using standby ac power furnished by the diesel generators in accordance with the loading sequence. One pump can be taken out of service by remote manual switching. The RBCCW system furnishes cooling water to the Reactor Recirculation pump seal water coolers and motor oil coolers. The drywell coolers (RB chilled water system) can be manually valved in after the RBCCW heat exchanger is manually switched from SW to ESW. A total heat load of 7.65×10^6 Btu/hr. would be transferred from the closed cooling water system to the emergency service water system at this time.

The remainder of the RBCCW system receives a reduced amount of cooling water; therefore, no appreciable heat load is transferred from the other RBCCW users. These users can be isolated manually from the system when required.

During loss of off-site power or loss of both Reactor Building chillers, the cleanup non-regenerative heat exchanger is automatically isolated from the RBCCW system.

During certain plant operating conditions, such as startup, excess water is normally removed from the reactor by blowdown through the reactor water cleanup system non-regenerative heat exchanger. During blowdown, the heat rejected to the RBCCW system is 25.19×10^6 Btu/hr. The second RBCCW heat exchanger may be put into service to handle this additional, transient heat duty.

The head tank, which is located at the highest point in the system, accommodates thermal expansion and provides ample net positive suction head (NPSH) to the cooling water pumps.

The head tank, which has a capacity of 800 gallons, also provides necessary makeup water as required.

The RBCCW supply and makeup is furnished from the demineralized water system. When required, chemicals are added to the system through the chemical addition tank (15 gal. capacity) to maintain a concentration of 500 ppm of nitrites for corrosion prevention.

The RBCCW system pumps, heat exchangers, chemical addition tank, and head tank are all located in the Reactor Building.

<u>9.2.2.3 Safety Evaluation</u>

The RBCCW has no safety-related function. Failure of the system will not compromise any safety-related system or component or prevent a safe shutdown of the plant.

The RBCCW system is not required to operate after a loss-of-coolant accident. The containment isolation valves will close automatically under this condition.

<u>9.2.2.4 Testing and Inspection Requirements</u>

The RBCCW system is hydrostatically tested prior to operation. The motor-operated containment penetration valves can be manually closed by the operator in the control room. These valves will be tested to assure that they are capable of opening or closing by operating the manual switches and observing the position lights in the control room.

Test connections are located inside containment to test and verify the leak tightness of the containment penetration isolation valves prior to operation.

The RBCCW system pumps, heat exchangers, head tank, chemical addition tank and piping (to the extent practicable) are located in the Reactor Building to permit periodic inspection during normal operation.

The system was preoperationally tested in accordance with the requirements of Chapter 14.

<u>9.2.2.5 Instrumentation Requirements</u>

The flow rate of cooling water to all coolers is regulated manually by individual throttling valves on the cooling water outlet from each unit. Flow elements are provided for the coolers located inside the primary containment for initial flow balancing of these components. A temperature indicator is provided on the RBCCW system header outside containment to verify satisfactory cooling of components inside containment. Temperature indicators are provided at the outlet of each cooler located outside primary containment except the off-gas precoolers and off-gas refrigeration condensers. Test points are furnished across all coolers in the system except the sample station chillers for pressure measurement.

Continuous radiation monitors are installed in the pump suction header of the RBCCW system. This instrumentation indicates, records, and alarms in the main control room any radioactive leakage into the RBCCW system.

High and low level switches on the RBCCW head tank detect leakage into or out of the system. Switch operation actuates an alarm in the control room. The RBCCW heat exchanger outlet

temperature and pressure are monitored. These signals alarm conditions of system high temperature and/or low pressure in the control room.

A low pressure switch is provided on the cooling water pumps discharge header to automatically start the standby pump in the event the system pressure drops below a preset value. The switch also actuates an alarm in the control room.

9.2.3 TURBINE BUILDING CLOSED COOLING WATER SYSTEM

9.2.3.1 Design Basis

The Turbine Building Closed Cooling Water (TBCCW) System has no safety related function and is a closed loop cooling system that transfers heat from miscellaneous turbine plant components to the service water system through the TBCCW heat exchangers.

The TBCCW system is required to operate during normal plant operation. During loss of offsite power, the TBCCW pumps are automatically loaded on the diesel generator and the TBCCW system will operate.

9.2.3.2 System Description

The TBCCW system consists of two 100-percent capacity cooling water pumps, two 100-percent heat exchangers, one head tank, one chemical addition tank, associated valves, piping and controls as shown on Dwg. M-114, Sh. 1. The system is designed to ANSI B31.1 requirements.

The TBCCW system furnishes cooling water to the following turbine plant components:

1) Control Rod Drive Pump Bearing and Oil Coolers
2) Condensate Pump Motor Upper and Lower Bearing Coolers
3) Instrument Air Compressor Coolers
4) Service Air Compressor Coolers
5) EHC Fluid Coolers
6) Turbine Building Sample Station Coolers and Chillers
7) Auxiliary Boiler Sample Station Coolers
8) Auxiliary Boiler Conductivity Monitoring Sample Coolers

During normal plant operation, one cooling water pump and one heat exchanger are in service. The second pump is on automatic standby. A heat load of approximately 1.1 x 10^6 Btu/hr is transferred from the closed cooling water system to the service water system in the heat exchanger. The water is circulated throughout the closed loop by the pump which is rated at 325 gpm at 120 ft of head. The capacity of cooling water required by each plant component is set by manual throttling valves located on the cooling water outlet of each unit.

The closed loop cooling water temperature leaving the TBCCW heat exchanger is automatically controlled by an air operated flow control valve located on the service water side. Automatic

control is carried out by a temperature indicating controller which maintains the closed cooling water outlet temperature at the Operator Adjustable Setpoint between 92 to 98°F.

After a loss of offsite power, the pumps start automatically to provide cooling water to the control rod drive pump bearing/oil coolers and the instrument air compressors as required. The TBCCW heat exchangers tube side flow may be transferred from the service water system to the emergency service water system by remote switching as permitted by system operating procedures. A heat load of 0.24 x 10^6 Btu/hr would be rejected from the control rod drive pump bearing/gear oil coolers and the instrument air compressors to the emergency service water at this time. TBCCW system operation is not required during a loss-of-coolant accident.

The head tank, which is located at the highest point in the system, accommodates thermal expansion and provides ample net positive suction head (NPSH) to the cooling water pumps. The head tank, which has a capacity of 400 gallons, also provides necessary makeup water as required.

The TBCCW supply and makeup is furnished from the demineralized water system. When required, chemicals are added to the system through the chemical addition tank (15 gal. capacity) to maintain a concentration of at least 500 ppm of nitrites for corrosion prevention.

The TBCCW system pumps, heat exchangers, chemical addition tank, and head tank are all located in the Turbine Building.

9.2.3.3 Safety Evaluation

Since the TBCCW system has no safety-related function, failure of the system will not compromise any safety-related system or component or prevent a safe shutdown of the plant.

9.2.3.4 Testing and Inspection Requirements

The TBCCW system is hydrostatically tested prior to operation. All portions of the system are accessible for visual examination and inspection during normal operation.

The system will be preoperationally tested in accordance with the requirements of Chapter 14.

9.2.3.5 Instrumentation Requirements

The flow rate of cooling water to all coolers is regulated manually by individual throttling valves on the cooling water outlet from each unit. Temperature indicators and test points for pressure measurements are provided on all coolers except the Turbine Building sample coolers and chillers.

High and low level switches on the TBCCW head tank detect leakage into or out of the system. Switch operation actuates an alarm in the control room. The TBCCW heat exchanger outlet temperature and pressure are monitored. These signals alarm conditions of system high temperature and/or low pressure in the control room.

A low pressure switch is provided on the cooling water pumps discharge header to automatically start the standby pump in the event the system pressure drops below a preset value. The switch also actuates an alarm in the control room.

9.2.4 GASEOUS RADWASTE RECOMBINER CLOSED COOLING WATER SYSTEM

9.2.4.1 Design Basis

The Gaseous Radwaste Recombiner Closed Cooling Water (GRRCCW) System has no safety related function and is a closed loop cooling system that transfers heat from the gaseous radwaste recombiner condenser condensate cooler, and motive steam jet condenser to the service water system through the GRRCCW heat exchangers.

The GRRCCW system is required to operate only during normal plant operation.

9.2.4.2 System Description

A separate GRRCCW system is provided for each of the three recombiner trains. Each closed cooling water system consists of one cooling water pump, one heat exchanger, one head tank, one chemical addition tank, associated valves, piping and controls as shown on Dwg. M-131, Sh. 1. The system is designed to ANSI B31.1 requirements.

The GRRCCW system furnishes cooling water to only its respective gaseous radwaste recombiner skid.

During normal operation when a recombiner train is in operation, the heat transferred from its respective GRRCCW system to the service water system is approximately 18.71 x 10^6 Btu/hr in the heat exchanger. The design of the heat exchanger is approximately 18.94 x 10^6 Btu/hr. At this time the single cooling water pump and heat exchanger are in operation. The cooling water pump is rated at 1450 gpm at a head of 100 ft. Since the recombiner skids are the only components on the GRRCCW system, no throttling valves are required for flow regulation.

The closed cooling water temperature leaving the GRRCCW heat exchanger is automatically controlled by a flow control valve located on the service water side. GRRCCW temperature is regulated to as low as possible down to 60°F minimum. When a recombiner train is in operation, the closed cooling water pump, which is started by manual initiation in the control room, circulates the cooling water throughout the GRRCCW system.

The head tank, which is located at the highest point in the system, accommodates thermal expansion and provides ample net positive suction head (NPSH) to the cooling water pump. The head tank, which has a nominal capacity of 400 gallons, also provides necessary makeup water as required.

The GRRCCW supply and makeup is furnished from the demineralized water system. When required, chemicals are added to the system through the chemical addition tank (15 gallons capacity) to maintain a concentration of 500 ppm of nitrites for corrosion prevention.

The GRRCCW system pump, heat exchanger, head tank and chemical addition tank are all located in the Turbine Building.

9.2.4.3 Safety Evaluation

Failure of the GRRCCW system will not compromise any safety-related system or component or prevent a safe shutdown of the plant.

9.2.4.4 Testing and Inspection Requirements

The GRRCCW system is hydrostatically tested prior to operation. In lieu of hydrostatic testing, alternate test/evaluation may be used provided the piping integrity is evaluated and dispositioned in accordance with 10CFR50.59. (See Reference 9.2-5) All portions of the system are accessible for visual examination and inspection during normal operation.

The system was preoperationally tested in accordance with the requirements of Chapter 14.

9.2.4.5 Instrumentation Requirements

A temperature indicator is provided at the outlet of the recombiner train. Test points are furnished across the recombiner train for pressure measurement. A flow element has been included in the system piping for flow determination.

High and low level switches on the GRRCCW head tank detect leakage into or out of the system. Switch operation actuates an alarm in the control room. The GRRCCW heat exchanger outlet temperature and pressure are monitored. These signals alarm in the control room conditions of system high/low temperature and low pressure.

The closed cooling water pump operation is controlled by a handswitch located in the control room. A low pressure switch located on the pump discharge header signals an alarm in the control room if system pressure falls below a preset value.

9.2.5 EMERGENCY SERVICE WATER SYSTEM

9.2.5.1 Design Bases

The Emergency Service Water System (ESWS) has a safety related function and is designed to supply cooling water to the emergency diesel generator units, RHR pumps, and to those room coolers (except for the emergency switchgear and load center room coolers, which are normally supplied by the control structure chilled water system in Unit 1 or the direct expansion (DX) cooling system in Unit 2) required during normal and emergency conditions necessary to safely shut down the plant.

The ESWS is designed to take water from the spray pond (the ultimate heat sink), pump it to the various heat exchangers and return it to the spray pond by way of a network of sprays that dissipate the heat to the atmosphere.

The ESWS is required to supply cooling water to:

a) The RHR pump room unit cooler and the motor bearing oil cooler of each RHR pump during all modes of operation of the RHR system.

b) All the heat exchangers associated with the four diesel generators aligned to the system during operation and test modes, except for the governor oil coolers.

c) The room coolers for the core spray (CS) pumps, the high pressure coolant injection (HPCI) pumps, and reactor core isolation cooling (RCIC) pumps during the operation of these systems.

d) The control structure chiller, the Unit 2 emergency switchgear cooling condensing unit, reactor building closed cooling water (RBCCW) heat exchangers, and the turbine building closed cooling water heat exchanger (TBCCW) during emergency operation.

e) The Spent Fuel Pools to provide makeup for evaporative losses during operation of the normal Fuel Pool Cooling system or RHRFPC mode, as well as, filling the SFP in support of RHRFPC. The ESWS is also capable of supplying makeup for postulated boiling conditions as described in Appendix 9A for a seismic event.

The ESWS starts automatically within approx. 40-100 seconds after the diesel generators receive their start initiation signal. The ESWS can also be started manually from either the main control room or from one of the two remote shutdown panels. (i.e., ESW loop A can only be started from the Unit 2 remote shutdown panel and ESW loop B can only be started from the Unit 1 remote shutdown panel.)

The ESW pump start sequence is controlled by a timer circuit in order to avoid unacceptable voltage drops. This timer circuit includes provisions to avoid simultaneous starts of the ESW, RHR, and CS pumps.

The ESWS is designed to operate during any of the following conditions:

a) Loss of offsite power

b) The operating basis earthquake (OBE)

c) Design high and design low level spray pond conditions.

It is also designed to remain functional following the design Safe Shutdown Earthquake (SSE).

The ESWS has sufficient redundancy so that a single failure of any active component, assuming the loss of offsite power, cannot impair the capability of the system to perform its safety related functions.

The system is designed so that the emergency service water is at a higher pressure than each of the fluids being cooled. This avoids the possibility of any radioactive leakage into the system. ESWS Pipe Crack Leakage Detection is discussed in Section 9.2.5.6.

The ESWS will operate under the conditions set by the design basis accident (DBA) for no less than 30 days with no water makeup to the spray pond. Under these conditions the pond's depth will always be greater than the minimum submergence of 7 ft required by the pumps (see Subsection 2.4.11.5).

Active components of the ESWS can be inspected and tested during plant power generation.

The system is designed for the 40 year life of the plant. Since the system must perform during the period of extended operation, aging of equipment is managed to ensure it continues to perform its intended function.

9.2.5.2 System Description

The ESWS is shown schematically in Dwgs. M-111, Sh. 1, M-111, Sh. 2, M-111, Sh. 3, and M-111, Sh. 4. The system consists of two loops each of which is designed to supply 100 percent of the ESW requirements to both units and the common emergency diesel generators simultaneously.

A fifth diesel generator (Diesel Generator 'E') is installed and serves as a replacement for any one of the normally aligned emergency diesel generators (A, B, C, or D). In the event that a diesel generator is removed from service for repair or maintenance, Diesel Generator 'E' can be aligned to the Class 1E power supply. Under these conditions, the normally aligned Loop A and B isolation valves at the disabled diesel generator are closed and the ESW Loop A and B isolation valves at the Diesel Generator 'E' are opened.

Whenever Diesel Generator 'E' is not aligned and in the test mode, it is connected to either Loop A or B of ESW system. The other four operable diesel generators (A, B, C and D) are normally aligned to the ESW Loop A and B system. In the event of an emergency start signal (LOCA or Loop) while Diesel Generator 'E' is operating in the test mode, the Diesel Generator 'E' Loop A and Loop B isolation valves will automatically close.

Each loop of the ESWS buried supply header and the RHRSW buried return header have connections as shown schematically in Dwgs. M-111, Sh. 1 and M-112, Sh. 1. Plant shutdown flow rates are listed in Table 9.2-3. Each loop has two 50 percent capacity, vertical, turbine type, single stage pumps operating at 1780 rpm and rated at 6000 gpm each. These are located in the engineered safeguard service water pumphouse which is built at the edge of the spray pond. Description of the pumphouse is found in Subsection 3.8.4.

The emergency service water flows through the tube side of all heat exchangers. The tubes in the air cooling coils for the ECCS and RCIC pump room coolers are constructed of AL-6XN, a high performance stainless steel that is resistant to Microbiologically Influenced Corrosion (MIC). All other heat exchangers, except those in the RHR pump motor coolers and diesel generator B&D jacket water coolers, have 90/10 Cu-Ni tubes. The RHR pump motor oil coolers and diesel generator B&D jacket water coolers utilize stainless steel (AL-6XN) tubes.

The supply and return piping is made of carbon steel with a 1/4 in. corrosion allowance. All piping outside of the pumphouse, main plant, and spray pond is buried and it is coated and wrapped for corrosion protection, except piping surfaces without coating that were evaluated and determined to be acceptable without further repair. Corrosion protection will be provided by the Catholic Protection system. Copper-copper sulfate reference electrodes are installed near the damaged pipe surfaces to monitor pipe to electrolyte potential which is indicative of level of corrosion protection to the pipe surfaces. The potential is monitored at regular interval selected for the Cathodic Protection system. Internal corrosion is being monitored through periodic non-destructive examination of in-plant piping, including ultrasonic measurement of wall thickness and radiography, at selected locations. This is supplemented by visual inspection of selected piping and components when opened for maintenance, and destructive examination of piping removed during maintenance or modification as appropriate. The inspection program is described in PPL Specification H-1019, Inspection Program for Piping Corrosion and Degradation.

If necessary, buried piping can be accessed for corrosion evaluations. The buried return pipe to the spray pond is predominantly 36 in. diameter, which can be entered and visually examined.

Manways with removable blind flanges are provided to allow periodic inspection of the inside of the pipe.

In-service inspection will be in accordance with ASME B&PV Code, Section XI for Section III, Class 3 components. The piping is designed, fabricated, inspected, and tested in accordance with requirements of ASME B&PV Code, Section III, Class 3. The spray pond piping network and ESSW pumphouse are described in Subsections 9.2.7 and 3.8.4 respectively.

During normal power generation the ESWS is not operating but is available for shutdown cooling, suppression pool cooling, surveillance testing or emergencies. The system is initiated automatically once the emergency diesel generators have started (see Subsection 9.2.5.1).

Following a loss of off-site power, ESW is protected from water hammer by two vacuum breakers installed on the control structure chiller return line and a check valve on its supply line. Additionally, Unit 2 ESW is protected from water hammer by a vacuum breaker installed on the return line of the direct expansion unit (Dx) and a check valve on its supply line.

The Emergency Condenser Water Circulating Pump (OP-171) is protected from being air bound after the vacuum breakers open by having the air purged from the return line (air can be introduced to the pump supply via the temperature mixing valve, TV 08612) before the pump starts.

Each of the two ESWS loops supply cooling water to separate equipment in each unit, except in the case of the common emergency diesel generators, RHR Pump 1P202C motor bearing oil cooler 1E217C, RHR Pump 1P202D motor bearing oil cooler 1E217D, RHR Pump 2P202C motor bearing oil cooler 2E217C and RHR Pump 2P202D motor bearing oil cooler 2E217D. This arrangement provides the necessary cooling capacity required by both units while maintaining the redundancy of active components and loops. The emergency diesel generator heat exchangers, RHR Pump 1P202C motor bearing oil cooler 1E217C RHR Pump 1P202D motor bearing oil cooler 1E217D, RHR Pump 2P202C motor bearing oil cooler 2E217C and RHR Pump 2P202D motor bearing oil cooler 2E217D are connected to both ESWS loops and they can be supplied by either.

It is not considered credible to have a common cause loss of the common RHRSWS/ ESWS loop that affects the systems capability to bring either or both units to a safe shutdown condition under emergency conditions. See 9.2.6.2.

Motors of the four ESWS pumps are connected to each of the four aligned diesel generator Unit 1 buses which serve as backup in the case of loss of offsite power. When loss of offsite power occurs, the four (4) aligned diesel generators start automatically and these provide emergency power for the pumps and motor operated valves. This transfer from the offsite power source to the standby power supply is automatic.

9.2.5.3 Safety Evaluation

The ESW system, with the exception of the buried piping and the piping in the spray pond, is housed within either the reactor building, the control structure, the diesel generator buildings or the ESSW pumphouse, all of which are Seismic Category I. Tornado protection is discussed in Section 3.3. Flood design is discussed in Section 3.4. Missile protection is discussed in Section 3.5. Protection against dynamic effects associated with the postulated rupture of piping

is discussed in Section 3.6. Environmental design considerations are discussed in Section 3.11.

Each unit has two 100 percent capacity independent ESWS loops to supply cooling water for plant shutdown. This arrangement ensures that the full heat removal capacity required is available after the postulated active failure of a single component.

Each loop is isolated from the other by barriers, separate trenches, or distance to ensure that simultaneous loss of both loops cannot occur.

Failure of either a motor operated valve, an aligned diesel generator, or an ESW pump, will not prevent the system from removing the full heat capacity.

Overpressure protection is provided in the portion of the ESW piping serving Diesel Generator 'E'. A thermal relief valve is utilized to prevent overpressurization following the operation of Diesel Generator 'E' and the subsequent closure of the Loop A and B isolation valves.

Upon loss of power, all safety related components (pumps, valves, and instruments) of this system will automatically be switched to the standby power supply (see Section 8.3).

Except for the Reactor Building Closed Cooling Water (RBCCW) heat exchanger and the Turbine Building Closed Cooling Water (TBCCW) heat exchanger, the entire ESWS including structures, pumps, motors, piping, valves, heat exchangers, and essential instruments are designed in accordance with Seismic Category I requirements. The RBCCW and TBCCW heat exchangers are not Seismic Category I since these are non-essential services. The RBCCW and/or TBCCW heat exchangers can be manually connected to one loop of ESW provided the other ESW loop is operable. Since the RBCCW and TBCCW heat exchangers are manually connected to the ESW after loss of off-site power, a failure of the non-safety related piping followed by a single failure in the safety related emergency service water system will not preclude one of the ESW loops from performing its safety function. If the single failure occurs in the emergency service water loop not connected to TBCCW or RBCCW, RBCCW and TBCCW will be manually isolated from the connected loop as permitted by system operating procedures. If the single failure is in the normally closed, fail closed isolation valve (between ESW and RBCCW/TBCCW), the remaining emergency service water loop would not be affected.

Operators will verify the integrity of the non-essential piping prior to valving it onto the ESW system.

The ESWS is designed to include the capability for testing through the full operational sequence that brings the system into operation for reactor shutdown and for LOCA, including operation of applicable portions of the protection system and the transfer between normal and emergency power sources.

The ESWS pumps, piping, and heat exchangers are sized to provide the flow and cooling capacities required by the various RHR pump and motor coolers during any mode of RHR operation. Tables 9.2-3, 9.2-4 and 9.2-5 show the users and cooling duties on the ESW cooling cycle.

Table 9.2-3 lists all users; Tables 9.2-4 and 9.2-5 relate users to time for two types of shutdown.

The cooling loads are carried out to 30 days after the shutdown initiation since this is the design life of the ultimate heat sink for operation without make-up water. The operation of all equipment listed at the cooling duty shown represents design conditions. Under actual operating conditions certain pieces of equipment may be shutdown or operated under reduced loads.

9.2.5.4 Tests and Inspections

The ESWS will be hydrotested in accordance with ASME Section III. Pipe welds are subjected to heat treatment, testing, and inspection according to ASME Section III and the material specification.

The system components will be preoperationally tested in accordance with the requirements of Chapter 14.

The ESWS will be tested during normal plant operations in accordance with the requirements of the Technical Specifications.

9.2.5.5 Instrumentation Applications

Logics and instrumentation are discussed in Subsection 7.3.1.1b and the displays are discussed in Section 7.5. A complete list of the system's safety related process instrumentation is provided in Table 7.5-5.

The ESWS pumps are designed for remote operation from the control room. Loop B can be remotely operated from the Unit 1 Remote Shutdown Panel, and Loop A can be remotely operated from the Unit 2 Remote Shutdown Panel. Each loop has been provided with a pump discharge pressure transmitter, the indicator for which is in the control room, and each pump chamber is provided with a low level submergence switch which alarms in the control room.

9.2.5.6 Pipe Crack Leakage Detection

Leakage from the ESWS can be detected by one of several methods depending on location. Leakage from piping within the ESSW Pumphouse drains into a pit which is equipped with a level switch to alarm on high water. The yard piping from the ESSW pumphouse to the pump discharge flow elements is contained in a guard pipe which drains back to the ESSW Pumphouse and into the same pit as described above. The remaining yard piping is located in a high traffic area and the presence of a significant leak will be visually apparent.

Leak detection within the Reactor Buildings, Control Structure and Diesel Generator Buildings differs depending on the location. Seismically analyzed room flood detectors are used in the lowest elevations, such as, the RHR, Core Spray, HPCI, RCIC and TBCCW Heat Exchanger rooms. Flood detection for the rooms containing ESW lines supplying the RBCCW heat exchangers, Control Structure Chillers, Unit 2 Dx units and Fuel Pool Makeup is not feasible nor desirable, since the lines are located in upper elevations of the Reactor Building and Control Structure. In these areas, floor drains route the leakage to radwaste via either the Reactor Building or Turbine Building sumps. The excessive influent into the radwaste system will alert operators to a pipe leak.

9.2.6 RHR SERVICE WATER SYSTEM

9.2.6.1 Design Bases

The Residual Heat Removal Service Water System (RHRSWS) has a safety related function and is designed to supply cooling water to the residual heat removal (RHR) heat exchangers of both units.

The RHRSWS is designed to take water from the spray pond (the ultimate heat sink), pump it through the RHR heat exchanger, and return it to the spray pond by way of a spray network that dissipates the heat to the atmosphere.

The RHRSWS is designed to provide a reliable source of cooling water for all operating modes of the RHR system including heat removal under post-accident conditions, RHR Fuel Pool Cooling (RHRFPC) following a seismic event, and also to provide water to flood the reactor core or the primary containment after an accident, should it be necessary.

The RHRSWS is designed to operate under any of the following conditions:

a) Loss of offsite power

b) Design high and design low level spray pond conditions

c) A safe shutdown earthquake (SSE).

The RHRSWS is designed with sufficient capacity and redundancy so that a single failure of any active component, assuming the loss of offsite power, cannot impair the capability of the system to perform its safety related functions.

A radiation monitor is provided in the RHRSW service water discharge piping from each RHR heat exchanger to alarm in the event of high activity level.

RHRSWS Pipe Crack Leakage Detection is discussed in Section 9.2.6.6. The RHRSWS is designed with the capability to operate under the conditions set by the design basis accident (DBA) for no less than 30 days without water makeup to the spray pond. The pond's depth will always be greater than the minimum submergence depth of 5 ft required by the pumps. (See Subsection 2.4.11.5.)
Active components of the RHRSWS can be inspected and tested during plant power generation.

The system is designed for the 40 year life of the plant. Since the system must perform during the period of extended operation, aging of equipment is managed to ensure it continues to perform its intended function.

9.2.6.2 System Description

The RHRSWS is shown schematically in Dwg. M-112, Sh. 1. The system consists of two RHRSWS loops (A and B) per unit. Each loop has a 100 percent capacity, vertical, turbine type two stage pump operating at 1180 rpm and a rated capacity of 9000 gpm. The Unit 1 A and Unit 2 A loop pumps are cross connected so that they can supply cooling water to either the Unit 1 A or the Unit 2 A loop heat exchanger. The same is true for the Unit 1 B and Unit 2 B loop pumps. The four RHRSWS pumps are located in the ESSW pumphouse at the edge of the

spray pond. A description of the pumphouse is found in Subsection 3.8.4. The RHR heat exchangers are described in detail under the RHR system.

The RHR service water flows through the tube side of the RHR heat exchangers, the tubes of which are made of corrosion resistant 70 - 30 Cu-Ni in accordance with ASME Section II, SB-395. The supply and return piping is made of carbon steel with a 1/4 in. corrosion allowance. All piping outside of the pumphouse, main plant, and spray pond is buried and it is coated and wrapped for corrosion protection. Piping surfaces found with damaged coating and or protective wrapping were left in as-found condition without any repair. Corrosion protection will be provided by the Cathodic Protection system. Copper-copper sulfate reference electrodes are installed near damaged pipe surfaces to monitor pipe to electrolyte potential which is indicative of level of corrosion protection to the pipe surfaces. The potential is monitored at regular interval selected for the Cathodic Protection system. Internal corrosion is being monitored through periodic non-destructive examinations of in-plant piping, including ultrasonic measurement of wall thickness and pipe radiography, at selected locations. This is supplemented by visual inspection of selected piping and components when opened for maintenance, and destructive examination of piping removed during maintenance or modification as appropriate. The inspection program is described in PP&L Specification H-1019, Inspection Program for Piping Corrosion and Degradation.

If necessary, buried piping can be accessed for corrosion evaluations. The buried return pipe to the spray pond is predominantly 36 in. diameter, which can be entered. Manways with removable blind flanges are provided to allow inspection of the inside of the pipe.

In-service inspection will be in accordance with ASME B&PV Code, Section XI for Section III Class 3 components. The piping is designed, fabricated, inspected, and tested in accordance with requirements of ASME B&PV Code, Section III, Class 3. The spray pond piping network and ESSW pumphouse are described in Subsections 9.2.7 and 3.8.4, respectively.

During normal power generation the RHRSWS is not operating, but is available for normal shutdown or emergencies.

When under emergency conditions, the RHRSW pump motors obtain their power from the standby power supply. The pumps are started manually 10 minutes after the diesel generators start. Waiting 10 minutes allows sequential loading of the diesel generators so that they will not be overloaded.

The buried pipe runs of each of the two RHRSWS loops are shared by both units and this provides the necessary capacity required for both units while maintaining the redundancy of active components and loops. Both the cooling water discharging from the RHR heat exchanger and the cooling water headers to the spray pond discharging from the corresponding ESW system are returned to the spray pond in a common header.

There are no credible single failures that can result in the loss of a common loop of RHRSW/ESW heat removal systems. There are no single active component failures that can cause this loss, no passive failures that could not be tolerated, and no operator error that could not be corrected in time to prevent plant or system damage.

Should the capability to remove decay heat from an unfaulted unit be lost, there is sufficient procedural and design capacity available to allow recovery of offsite power, repair of single failure or recovery from operator error.

Single failure coping can be accomplished with existing procedures. The Primary Containment Control Emergency Operating procedure leads directly to containment protection actions in the event of high drywell pressure and temperature. These actions permit extended operation without heat removal and assure maintenance of adequate core cooling. Extended duration without containment heat removal has been evaluated for the more extreme case of the station blackout, where containment integrity and adequate core cooling can be maintained indefinitely provided that the containment is vented according to the procedure. In addition, a distribution manifold is provided on each division of the Unit 2 RHRSW system to support plant shutdown under extended loss of AC power conditions. The distribution manifold can be used to provide cooling water to the RCIC lube oil cooler, RHR pump motor oil cooler and RHR pump room cooler under extended loss of AC power conditions. Normally closed isolation valves are provided on each manifold connection point. No RHRSW distribution manifold is installed in Unit 1. In Unit 1, cooling to the RHR pump motor oil cooler and RHR pump room cooler are provided from valves 112077 (Division 1) or 112084 (Division 2) under extended loss of AC power conditions. Cooling to the RCIC lube oil cooler is provided from valves 112017 (Division 1) or 112023 (Division 2) under extended loss of AC power conditions. The redundant fuel pool makeup connection points provided on the Unit 2 RHRSW distribution manifold can provide makeup to both Units spent fuel pools under extended loss of AC power conditions; therefore no Unit 1 fuel pool makeup connections are required.

The defense in depth is therefore maintained for the decay heat removal capability. Design requirements for the heat removal capability specifically require design tolerance of single failures under DBE conditions. The decay heat removal systems are suitably designed, as required by General Design Criteria 38 and 44, to tolerate credible single failures without loss of the capability, and the plant is suitably designed to tolerate a temporary loss of the capability for a reasonable duration as may be required to recover the plant heat removal systems.

Motors of the four RHRSWS pumps are connected to each of the four diesel generator buses that serve as backup in the case of loss of offsite power. When loss of offsite power occurs, the diesel generators start automatically, providing emergency power for the pumps and motor operated valves. This transfer from the offsite power source to the standby power supply is automatic. Although the transfer from offsite power to standby power supply is automatic, the pumps themselves have to be started manually.

To prevent freezing, there is provision for draining the piping in the spray pond.

9.2.6.3 Safety Evaluation

The RHRSW system, with the exception of the buried piping and the piping in the spray pond, is housed within either the reactor building or ESSW pumphouse, both of which are Seismic Category I. Tornado protection is discussed in Section 3.3. Flood design is discussed in Section 3.4. Missile protection is discussed in Section 3.5. Protection against dynamic effects associated with the postulated rupture of piping is discussed in Section 3.6. Environmental design considerations are discussed in Section 3.11.

Each generating unit has two independent RHRSWS loops, one for each RHR heat exchanger, to supply cooling water for plant shutdown. This arrangement ensures that the full heat removal capacity required is available after the postulated active failure of a single component.

Each loop is isolated from the other by barriers, separate trenches, or distance to ensure that simultaneous loss of both loops cannot occur.

Failure of either a motor operated valve, a diesel generator, or RHRSW pump will not prevent the system from removing the full heat capacity.

The entire RHRSWS including structures, pumps, motors, piping, valves, heat exchangers, and essential instruments are designed in accordance with Seismic Category I requirements.

The RHRSWS is designed to include the capability for testing through the full operational sequence that brings the system into operation for reactor shutdown and for LOCA, including operation of applicable portions of the protection system and the transfer between normal and emergency power sources.

The RHRSWS pumps, piping, and heat exchangers are sized to provide the flow and cooling capacities required by the RHR system during any mode of its operation. Tables 9.2-3, 9.2-4 and 9.2-5 show the users and cooling duties on the ESW cooling cycle.

Table 9.2-3 lists all users; Table 9.2-4 and 9.2-5 relate users to time for two types of shutdown.

9.2.6.4 Tests and Inspections

The RHRSWS will be hydrotested in accordance with ASME Section III. Pipe welds are subjected to heat treatment, testing, and inspection according to ASME Section III and the material specification.

The system will be preoperationally tested in accordance with the requirements of Chapter 14.

The RHRSWS will be tested during normal plant operations in accordance with the requirements of the Technical Specifications.

9.2.6.5 Instrumentation Applications

Logics and instrumentation are discussed in Subsection 7.3.1.1b and the displays are discussed in Section 7.5. A complete list of the system's process instrumentation is provided in Table 7.5-1.

The RHRSWS pumps are designed for remote operation from the control room. One loop from each unit can be remotely operated from either of the two remote shutdown panels. Each pump has been provided with a discharge pressure transmitter, the indicator for which is in the control room. Each pump chamber is provided with a low level submergence switch that alarms in the control room.

The main water supply line to each heat exchanger is instrumented with control room mounted flow indication, low flow alarm, high temperature alarm, and low pressure alarm. Each heat exchanger has control room operated isolation valves on the inlet and outlet, which remain closed until the system is operated or tested.

Double remotely operated isolation valves are provided on the cross-tie lines between the RHRSW system and the RHR pump discharge for flooding the containment if such action is necessary and no other source of water is available.

9.2.6.6 Pipe Crack Leakage Detection

Leakage from the RHRSWS can be detected by one of several methods depending on location. Leakage from piping within the ESSW Pumphouse drains into a pit which is equipped with a seismically analyzed flood detector. The yard piping from the ESSW pumphouse to the pump discharge flow elements is contained in a guard pipe which drains back to the ESSW Pumphouse and into the same pit as described above. The remaining yard piping is located in a high traffic area and the presence of a significant leak will be visually apparent.

The RHRSW piping in the Reactor Buildings are located within the RHR rooms which are designed as watertight compartments, as discussed in Section 3.4. Leakage into the rooms will be detected by seismically analyzed room flood detectors.

9.2.7 ULTIMATE HEAT SINK

The ultimate heat sink has safety related functions and provides cooling water for use in the Emergency and RHR Service Water systems, described in Subsections 9.2.5 and 9.2.6, during ESSW testing, normal shutdown, and accident conditions.

9.2.7.1 Design Bases

The ultimate heat sink is capable of providing sufficient cooling water without makeup to the spray pond for at least 30 days to (a) permit simultaneous safe shutdown and cooldown of both nuclear reactor units and maintain them in a safe shutdown condition, (b) mitigate the effects of an accident in one unit, permit safe control and cooldown of the other unit, and maintain it in a safe shutdown condition or (c) permit simultaneous safe shutdown and cooldown of both units and maintain them in safe shutdown while providing adequate cooling to both spent fuel pools following a seismic event. Continued cooling beyond 30 days is ensured by use of the makeup pumps to keep the pond at normal water level. The makeup pumps are designed to operate below the historic minimum water level of the Susquehanna River. In the event that makeup water from the makeup pumps is not available, additional provisions will be made in the 30 days available to assure continued cooling of the emergency equipment beyond 30 days. These provisions include but are not limited to: re-establishing makeup pump flow to the spray pond, emptying the cooling tower basins into the spray pond, trucking in water from neighboring water sources (such as the Susquehanna River), and providing temporary pumps and/or lines to pump water from neighboring water sources (such as the Susquehanna River, on site storage tanks, well water, etc.). This is in compliance with NRC Regulatory Guide 1.27 Rev. 2 as discussed in Section 3.13.

The ultimate heat sink is also capable of providing enough cooling water without makeup, for a design basis LOCA in one unit with the simultaneous shutdown of the other unit, for 30 days while assuming a concurrent SSE, single failure, and loss of offsite power. This event is evaluated in Subsection 9.2.7.3.1.

The ultimate heat sink consists of at least one highly reliable water source with a capability to perform the safety function required above during and after any one of the following postulated design basis events:

a) The most severe natural phenomena, including the safe shutdown earthquake, tornado, flood, or drought taken individually

b) Nonconcurrent site related events including loss of offsite power, transportation accidents, or oil spills and fires

c) Reasonably probable combinations of less severe natural phenomena and/or site related events

d) Any credible single mechanistic failure of a man-made structure or component.

Codes and standards applicable to the ultimate heat sink are listed in Table 3.2-1.

9.2.7.2 System Description

9.2.7.2.1 General Description

The ultimate heat sink for both units consists of the Susquehanna River and one Seismic Category I spray pond. These water sources ensure that a reliable source of cooling water is available, for shutdown and cooldown of the reactor, and for mitigation of accident conditions. Pertinent design data for ultimate heat sink components is given in Tables 9.2-6 and 9.2-7.

The spray pond is initially filled from the Susquehanna River by four makeup water pumps. Pond level is maintained under normal conditions by rainfall on the pond surface (46 inches per year average) and by a small continuous flow of makeup water from the Susquehanna River. The average rainfall will generally exceed the average evaporation from the pond by 2 million gallons per year. This excess rainwater will tend to decrease the concentration of total dissolved solids (TDS) in the pond. This decrease is offset by evaporative losses and by the ingress of more concentrated cooling tower basin water from ESW keepfill, valve leakage and hot circulating water. The hot circulating water, at a flow rate of less than 100 gpm, is used as required to de-ice the screens at the pump suctions. The concentration of dissolved solids will be between that of the river water and the water in the cooling tower basis, depending upon the quantity of heat rejected to the pond, evaporative losses, blowdown and other liquid losses, and the ratio of river water makeup to circulating water ingress.

During an emergency, accompanied by the loss of makeup pumps, up to 67% of the pond water may be lost by evaporation over 30 days, assuming conditions that maximize evaporative losses. This would approximately triple the concentration of dissolved solids in the pond. Liquid losses under these conditions can increase the total losses to a maximum 96% of the initial volume, which will further increase concentration.

Shortly after a DBA, heat transfer surfaces in ESW and RHRSW can approach 150°F. Concentration of pond water can cause scale (calcium carbonate) to form on hot surfaces. Pond chemistry will be controlled during normal operation so that no operator action will be needed to prevent scaling during the first week following the initiation of an emergency condition. After the first week, acids and/or scale inhibiting chemicals can be added to prevent scaling until makeup becomes available.

During normal operation, pond water chemistry is monitored periodically by grab samples. Pond chemistry is adjusted by dilution, acid addition, and/or the addition of scale inhibitors, so that scaling will not occur at 150°F assuming that the pond is concentrated by a factor of 1.25. This is the maximum pond concentration factor after seven days of an emergency condition without makeup.

The PSAR described the flow of cooling tower blowdown through the spray pond and then to the river. This original routing was selected for environmental reasons. The EROLS section 10.10 now states that the cooling tower blowdown bypasses the pond and flows directly to the river. This revised routing has been selected based upon a reassessment of environmental considerations of flow through the pond. The direct route to the river also eliminates many of the temperature and chemical problems of spray pond water management.

9.2.7.2.2 Component Description

Generally the ultimate heat sink consists of a concrete lined spray pond covering approximately 8 acres and containing 25,000,000 gallons of water, and an ESSW intake structure housing four RHRSW pumps and four ESW pumps which pump the water from the pond through their respective loops and back to the pond through a network of sprays located in the pond. The pond and ESSW pumphouse are described in more detail in Subsection 3.8.4.1 and shown on Dwgs. M-284, Sh. 1, C-64, Sh. 1, C-65, Sh. 1, C-66, Sh. 1, and C-67, Sh. 1.

The spray pond is a Seismic Category I design excavated below grade and has a normally maintained water level of 678.5 ft MSL. The spray pond water volume is adequate for 30 days of cooling without any makeup, as demonstrated in Subsection 9.2.7.3. The spray pond is concrete lined to minimize seepage.

The ESSW intake structure which houses the RHRSW pumps and ESWS pumps is located on the spray pond so that a positive water supply is provided at all times to each pump suction. The pumps are the vertical type and the pump pit dimensions are such that the required NPSH for each pump is ensured even at the minimum water level. The spray pond location is shown in Section 1.2. The ESSW intake structure is Seismic Category I and its design is explained in Subsection 3.8.4.

The spray system for the pond consists of one Seismic Category I network for each ESSW service water train. The system is designed so that the pressure drop across the spray nozzles necessary for proper spray performance is achieved for all anticipated modes of RHRSW and ESW operation. The nozzle, Spray Engineering Model 1751A, is shown in Figure 9.2-23. The nozzles are precision-cast and are of a design that provides good thermal performance while minimizing drift loss. The nozzles have no internal parts that are susceptible to clogging. The piping in the spray system is designed and installed in accordance with ASME Section III, Class 3.

Four one-third capacity 13,500 gpm 315 ft. head, motor driven pumps are located in the river intake structure. They supply makeup water to the entire plant through a buried line sized to provide sufficient water to replenish the losses resulting from normal operating plant demands such as the cooling tower basins as well as makeup to the spray pond. An 18 in. makeup connection to the spray pond is tapped off the main 42 in. supply line at a point close to the spray pond. The makeup line, which is also used for de-icing, is arranged in such a manner as to avoid the possibility of water draining from the pond if a failure occurs in the makeup supply system. This line is used to fill the pond initially and to refill it following its use as the result of an emergency. When the pond is not in use the only loss is by evaporation, which is made up by rainfall and a continuous flow of water through a 4 in. bypass line around the closed isolation valve in the 18 in. makeup line. Any excess water in the pond flows over a weir and back to the river. Meteorology for the area indicates that rainfall is expected to add more water to the pond than is lost by evaporation.

9.2.7.2.3 System Operation

Summer Startup and Operation

System operation is controlled to ensure that the Ultimate Heat Sink design temperature will not be exceeded. The temperature conditions that could exist in the pond during summer startup will be less severe than the conditions that could exist during summer operation. No attempt will be made to start up either unit if the pond is not at the minimum specified level in Technical Specifications.

During plant startup and summer operation when high ambient wet bulb temperatures and non-spray conditions exist, the pond temperature will approach an equilibrium temperature which is the temperature a stagnant body of water will reach after prolonged exposure to ambient conditions. The maximum Susquehanna pond temperature was calculated to be 89°F under these conditions.

Under normal plant operating conditions, the maximum pond temperature will approach the equilibrium temperature. Operating procedures control the RHRSW and ESW total return flow inventory through either the system spray network or direct pond discharge path as required to maintain Ultimate Heat Sink temperature within the design operating range.

Technical Specifications limit plant operation if the pond bulk temperature reaches 85°F. This temperature has been calculated to be the maximum allowable starting temperature to maintain the engineered safeguard service water (ESSW) temperature, under worst case meteorological and plant accident conditions, consistent with the ESSW design basis, as shown in Figure 9.2-21 for maximum temperature and Figure 9.2-22 for Ultimate Heat Sink inventory control.

Winter Startup and Operation

Startup of either unit will not be initiated unless the spray pond, spray network, and pumping system are available for operation.

At times of subfreezing temperatures, procedures will be enforced to prevent icing of the spray system. These consist primarily of the following:

a) The total return flow of both the RHRSW and ESW pumps will be first discharged directly into the pond, through a bypass line, without passing through the spray network. This will permit the operation of the pond if nozzles become covered with ice from, for example, a freezing rain. As the water temperature in the pond increases, conduction of heat to the nozzle will melt any accumulated ice. The bypass lines enter above the pond level so that they drain to prevent freezeup and therefore always assure a flow path for the ESW & RHRSW. The bypass lines are located as shown in Figure 9.2-24-1, approximately 400 feet away from the pump suctions. The physical distance between the pump suctions (which are kept ice free) and the return lines makes the probability of increasing the water temperature of the pump suction above the design maximum temperature due to short circuiting negligible, even if the pond surface does not thaw significantly. An overview of the pond piping and bypass lines is shown on Figure 9.2-24-1. The bypass lines are numbered as 36" HRC-1 and 36"HRC-2.

b) Portions of the nozzle header and riser system that are located above pond water level can be drained when not in service. Draining is performed during the winter months after the sprays are operated or when leakage through the spray array isolation valves creates the potential to freeze the spray array piping. Draining is accomplished by pumping the water out of the spray arrays from low points in the piping. This can be done manually or automatically.

   Each division of sprays has an active drain pump and an installed spare. The pumps take suction from 3 inch drain lines that originate at low points in the piping for each spray array. Each drain line is isolated from its associated pump by a motor operated drain valve. The pumps and drain valves are located in the spray pond valve vault.

c) The majority of the water distribution system associated with the ultimate heat sink will be either buried below the frost line or located inside heated buildings and therefore not exposed to freezing problems.

d) Any sections of the piping which are either not within buildings, or drainable will be electrically traced to protect against freezing. The electrical supply for the tracing is not supplied from the diesel generators since, in the event of auxiliary power loss, heated water will be flowing in the piping that is traced.

The maximum expected ice thickness, assuming there is no heat load on the spray pond, is estimated to be 22 inches, which agrees closely with the maximum expected ice thickness based on probability studies that used field data for colder regions of North America.

The extreme weather conditions used for the above analysis were obtained from meteorological records and were based on the month having the lowest average dry bulb temperature. This average temperature was used for the analysis and the resulting estimate of maximum ice thickness is therefore conservative.

With the extreme (cold) meteorological conditions considered, no provision is made to prevent freezing of the spray pond surface if both units were shut down at the same time. However, freezing of the pond when the units are shut down is not a safety concern.

9.2.7.3 Safety Evaluation

The ultimate heat sink spray pond is capable of providing enough cooling water to safely shut down and cool down both reactors, without the addition of makeup water, for 30 days concurrent with any of the following postulated design basis events:

a) SSE, flood or drought.

b) Any single site related event.

c) A reasonably probable combination of less severe natural phenomena and/or site related events.

d) Man-made structural features of the spray pond are designed considering all conceivable failure mechanisms, including the SSE and design basis tornado effects. Conservative allowances are added to the spray pond water volume as shown in Table 9.2-8.

Where the above design events could result in the loss of offsite power, such a loss is assumed. In addition, a single failure is postulated.

The ESSW intake structure is located directly adjacent to the spray pond; therefore, no canals, conduits, or waterways are associated with or required to ensure positive water flow to the suction of the RHRSW pumps and ESW pumps.

The pumps for each loop are in separate closed rooms within the ESSW pumphouse. There are no communication pathways between pump rooms. Internal flooding due to a leaking crack in the moderate energy piping would be mitigated by four 3' by 3' openings with gratings which drain to the spray pond. The pump room doors are at an elevation 3 inches higher than the drains to contain the leakage, estimated at less than 1600 gpm within the room. Therefore, flooding in one pump room will have no effect on the safe shutdown capabilities of the other loop.

If a tornado passes over the site and causes a loss of water from the spray pond, makeup water will be provided by either the makeup water pumps or in an extreme emergency the cooling tower basins. The minimum operating water elevation in the spray pond will be 678'-1" MSL. The maximum anticipated elevation will be 682.3' which occurs under PMF conditions. The only postulated exception to these limits is that during the event of a tornado passing over the pond, the water level may temporarily be lower than elevation 678'-1".

The power supply to the motors for the makeup water pumps is provided from an offsite power source through underground cables. Even if one of the makeup pumps fails, a sufficient flow of water to the spray pond is ensured since each of the four pumps is designed to deliver one-third of the total plant makeup flow requirement.

All spray network headers are located in concrete trenches at the bottom of the spray pond and covered with concrete 18" thick to resist the impact of a tornado missile.

The spray pond and its associated ESSW intake structure are protected from the maximum probable flood level as discussed in Subsection 2.4.8 if a flood requires shutdown of the plant.

The spray pond is designed to contain the total volume of water required for 30 days of cooling without makeup. After 30 days water will be available from the river for makeup to the pond for long-term cooling. The Susquehanna River is a reliable source of water even during a severe drought (see Section 2.4). As a result of the reliability of the river and the spray pond, a drought has no impact on the operation or shutdown of the plant. The potential for incapacitating accidents on the site has been evaluated and is discussed in Section 2.2. The physical remoteness of the ultimate heat sink to the avenues used for bulk petroleum transportation makes massive fouling of the heat sink surface by an oil spill unlikely. Vehicles delivering diesel fuel oil to the site will not be permitted to remain in the area of the ultimate heat sink in order to prevent an accident involving the delivery vehicle, which could result in an oil spill.

A fire would have minimal impact upon safe shutdown cooling, inasmuch as the ultimate heat sink and related equipment are largely heat resistant or noncombustible. However smoke detectors are installed inside the ESSW intake structure and CO fire extinguishers are located there. A hydrant is also available adjacent to the structure.

The credible failure of a man-made structural feature will not result in the loss of the ultimate heat sink safety function. The lined spray pond is constructed by excavation and is not subject to catastrophic failure (see Subsection 2.5.5).

9.2.7.3.1 30-Day Transient

The Seismic Category I spray pond has enough water available for at least 30 days without makeup and the design maximum cooling water temperature is 97°F which is based on the worst atmospheric conditions on record. Analyses have been performed to demonstrate the ability of the spray pond to meet these criteria.

In analyzing the ability of the spray pond to dissipate the heat rejected from both the RHRSW and ESW systems, alternative 30 day transients have been considered. The method of analysis is presented in Subsection 9.2.7.3.2, and a discussion of the conservatisms used is included in Subsection 9.2.7.3.7. Calculation results are shown in Figures 9.2-21 and 9.2-22.

An analysis of the 30 day transient coincident with loss of offsite power to both generating units is presented below.

If both generating units have been operating at full power and a LOCA occurs on one unit, followed by a forced shutdown (without offsite power) on the second, the following sequence of events is assumed to occur:

a) Both reactors would be scrammed and both turbine-generators isolated.

b) The loss of power would cause loss of makeup and circulating water and loss of condenser vacuum on both units. Loss of the main condenser places maximum heat dissipation requirements on the ultimate heat sink.

c) Safeguard equipment, common to both units, would be actuated (four diesels, four ESW pumps).

d) On the unit experiencing the LOCA, all safeguard equipment would be actuated (four core spray pumps, four RHR pumps, ADS, and HPCI).

e) On the unit undergoing the forced shutdown due to loss of offsite power, the RCIC system would actuate to hold reactor water level while the safety relief valves limit reactor pressure.

f) All supporting systems associated with the above steps would be brought into service (e.g., diesel-generators, emergency service water, RHR service water).

The occurrence of the accident automatically initiates safeguards operation. After 10 minutes, the equipment is operator controlled and, by defining the time these operations are started, the heat rejected to the ultimate heat sink is established. This complicates the analysis and necessitates the study of alternative means of shutdown to determine which result in the limiting heat sink criteria.

The maximum heat load to the spray pond will occur with a LOCA/Forced Shutdown combination, as opposed to a two unit forced shutdown. Two different LOCA/Forced Shutdown scenarios were developed for this analysis. The shutdown scenario for the minimum heat transfer case assumes spray and bypass array configuration that maximize spray pond

temperature. The shutdown scenario used for the minimum heat transfer case is shown in Tables 9.2-4 and 9.2-21. The shutdown scenario developed for the maximum water loss case assumes the availability of both spray networks, thereby maximizing drift losses. The maximum water loss shutdown scenario is shown in Tables 9.2-5 and 9.2-21a.

The most stringent criteria were used in the analysis and the results demonstrated the ability of the Susquehanna SES spray pond to meet the performance requirements of an ultimate heat sink.

9.2.7.3.2 Methods of Analysis

The analysis is directed at providing sufficient information to define the following three parameters:

a) Pond surface area
b) Pond water volume
c) Nozzle arrangement

Input Parameters

Heat rejection after the postulated accident during the shutdown sequence is due to decay heat, sensible heat, and auxiliary system heat loads. The analysis decay heat is based on the methods described in ANSI/ANS 5.1 – 1979, "American National Standard for Decay Heat Power in Light Water Reactors". The decay heat data is presented in Table 9.2-19. The values listed in Table 9.2-19 include fission product and heavy element contributions to the heat generation rate. Sensible heat release is included in the mathematical treatment of the heat removal system model. The emergency service water system heat loads are presented in Table 9.2-20.

The cooling system flow rates released as heat loads to the pond are tabulated in Table 9.2-21 for the RHR and RHR Service Water Systems and in Table 9.2-22 for the Emergency Service Water System.

The initial conditions assumed for the heat removal system model are listed in Table 9.2-23. The results of the containment analysis was used to determine containment initial conditions (10 minutes after LOCA for this analysis).

The input parameters used in the spray pond thermal efficiency calculations and drift loss calculations are based on spray pond geometry, assumed shutdown sequence, and synthesized meteorology.

Pond Surface Area

Sufficient area is provided to allow the full complement of spray nozzles to be located on the pond surface.

Sufficient area is provided to ensure that the distance of the outermost line of nozzles to the edge of the pond is great enough to prevent unacceptable water losses that result from drift.

Pond Water Volume

Pond water volume has been selected such that the water losses listed in Table 9.2-8 can be experienced over the 30 day transient period while the pond is still able to perform the necessary cooling duty until the end of the 30th day. Sufficient water is provided to ensure that the sensible heat capacity of this heat sink, together with the cooling ability of the nozzles, are sufficient to keep the temperature of water supplied to the equipment below the design temperature of the equipment. Ensuring that the design temperature is not exceeded is essential in meeting manufacturers' recommendations for equipment and also in limiting the containment transient temperatures that are dependent on the RHR service water temperature.

The spray pond volume and network are designed to maintain the maximum Emergency and RHR Service Water temperature, under worst case meteorological and plant accident conditions, consistent with the Emergency and RHR Service Water design basis, as in shown in Figure 9.2-21 for maximum temperature and Figure 9.2-22 for inventory control.

An overflow weir fixes the level of the pond as water is continuously introduced through a 2 in. bypass line around the isolation valve in the 18 in. makeup line; thus, the minimum level is always maintained while either unit is operating. (See Subsection 2.4.8.)

Nozzles and Nozzle Arrangement

Nozzles and nozzle arrangement, shown in Figures 9.2-23, 9.2-24-1, 9.2-24-2, and 9.2-24-3 are selected such that the optimum heat dissipation is reached, satisfying the following requirements:

a) There are sufficient nozzles to dissipate the maximum heat load resulting from the emergency shutdown operation without allowing the pond temperature to exceed the maximum permissible as discussed above.

b) The nozzles are as close to one another as possible without hindering individual performance.

c) The spray pressure at the nozzles has been selected to optimize the water droplet surface area for heat rejection while minimizing small droplet generation that would increase drift losses. The selected nozzle was chosen because of the experience of the supplier, wide use of this particular nozzle, and a spray pattern close to optimum for minimum drift with maximum thermal dissipation.

d) The piping distribution system supplying the nozzles is arranged to permit isolation of nozzle networks. This will permit startup and shutdown of selected RHRSW or ESW pumps throughout the 30 day transient, while maintaining optimum nozzle pressure.

The large number of parameters associated with the above basic variables necessitated the development of analytical models suitable for computer use. There are three principle models and these are outlined below.

9.2.7.3.3 Pond Performance Models

The analysis of the SSES emergency cooling water system is based on three computer models: the spray cooling thermal performance model, the drift loss model, and the system response model. Each of these models are discussed individually.

Use of the three models requires input details on ambient conditions and these have been prepared by PPL's meteorological consultant, Ford, Bacon & Davis. A discussion of the use of the meteorology report is presented in Subsection 9.2.7.3.5.

Spray Cooling Thermal Performance Model

The performance of the spray pond depends on many parameters, such as spray array geometry, drop size spectrum, wind velocity, atmospheric conditions and spray height. All the controlling parameters have been included in the computer model as described below.

The thermal performance model predicts the cooling capability of the spray arrays and the evaporation rate due to spray cooling.

Separate thermal performance models are used to predict the overall cooling capability of the spray arrays for high wind speeds and low wind speeds.

The computer model developed for this analysis includes the effects of the following parameters:

1. Drop mean diameter.
2. Wind speed and direction.
3. Air dry bulb temperature.
4. Air wet bulb temperature or relative humidity.
5. Height of nozzles above water level.
6. Pressure drop through the nozzle or height attained by the spray.
7. Dimensions of the spray volume.
8. Water flow rate in spray volume.

For high wind speeds (above 3 mph approximately), the heat transfer mechanism is assumed to be forced convection. For low wind speeds cooling is assumed to be by natural convection only. The individual spray patterns are lumped together to form the spray volume which is divided into a number of increments in the direction of the air movement. The temperature and vapor content of the air in each increment is assumed to be uniform within the increment and is numerically the same as that exiting the preceding increment. The sprayed water temperature, air temperature, and air moisture content for each increment is calculated and the results combined to yield an average sprayed water temperature for the spray volume. A critical aspect of the calculation is the determination of the evaporation rate within the increment. The empirical work of Ranz and Marshall (Ref. 1 of Question 371.18) on droplet heat and mass transfer was used as the basis for the evaporation rate and air temperature calculations. In their experiments, Ranz and Marshall suspended a drop from a capillary tube, supplied a known air flow over the drop surface, and measured the drop temperature, air temperature, drop diameter (held constant with water flow through the capillary tube from a microburet), and make-up flow rate from the microburet. In this way the heat transfer coefficients were derived by correlation with the data.

The increment mass and energy balance used in the calculation of spray cooling efficiency is shown schematically in Figure 9.2-17. Water enters the increment through the spray nozzles and exits the increment after undergoing mass and energy transfer. The amount of mass and energy transferred is calculated from heat and mass transfer coefficients derived empirically:

$$N_{NU} = \frac{h_c D}{K} = 2.0 + 0.6\{N_{PR}\}^{1/3}\{N_{RE}\}^{1/2}$$

$$N_{SH} = \frac{h_d D}{D_v} = 2.0 + 0.6\{N_{SC}\}^{1/3}\{N_{RE}\}^{1/2}$$

where

N_{NU}	=	Nusselt number
N_{SH}	=	Sherwood number
h_c	=	Heat transfer coefficient for conduction and convection
h_d	=	mass transfer coefficient
D	=	drop diameter
K	=	thermal conductivity of air-vapor moisture
D_v	=	diffusivity of vapor in air
N_{PR}	=	Prandtl number
N_{RE}	=	Reynolds number
N_{SC}	=	Schmidt number

The energy transfer rate is the sum of contributions from conduction, convection and evaporation. The lifetime of a drop in the increment, calculated from the pond geometry and other parameters affecting the drop trajectory, is used with the energy transfer rate to determine the temperature of the cooled water leaving the increment. The moisture content of the air leaving the increment is determined from the mass transfer (evaporation) rate and the air flow rate (residence time of the air in the increment). The temperature of air exiting the increment is calculated from an energy balance on the increment. The exit air temperature and moisture content for increment i is used in increment i + 1 to determine the heat and mass transfer rate in that increment. This process is repeated until all the increments have been treated.

At low wind speeds (less than approximately 3 mph), air enters the spray volume from all sides rather than one; therefore, the increment definition used for low wind speeds is rectangular, like a picture frame. The air velocity entering each increment is determined from the density difference between the air-vapor mixture in the increment and the ambient.

Spray efficiencies for wind speeds below 3 mph are calculated assuming natural convection only. Spray efficiencies for wind speeds greater than or equal to 3 mph are calculated

assuming forced convection only. This procedure shows good agreement with the test results and avoids excessive conservatism.

The results of the calculation described above is a set of cooled water temperatures, one for each increment. Since the air temperature and moisture content for each increment is different, the cooled water temperatures are different. The average cooled water temperature, T, is calculated.

where

$$\bar{T} = \sum_{i=l}^{N} \frac{Ti}{n}$$

T_i = incremental cooled water temperature,

n = number of increments in the spray volume

The thermal efficiency, E_{th}, is calculated from the ambient air wet bulb temperature, T_{wb}, and the water temperature before spraying, T_s.

$$E_{th} = \frac{T_s - \bar{T}}{T_s - T_{wb}}$$

The primary conservatism in the thermal performance prediction model is the lack of convective air motion into the spray volume, (for all but very low wind speeds) which results in lower calculated efficiencies. The convective air motion is most important at low wind speeds; consequently, the degree of conservatism increases as wind speed decreases. Since thermal performance at low wind speeds is most important, this is a desirable effect as long as the degree of conservatism is not unrealistic. Data taken at existing spray ponds has been used to demonstrate the degree of conservatism of the model.

In the model the temperature of the water being sprayed is calculated using an iterative technique based on the temperature of the pond and the heat addition to the spray water at each increment in time. If the heat dissipated by the sprays is less than that added to the system, the temperature of the water entering the pond after spraying is higher than the bulk pond temperature. As a result, the pond temperature increases until the heat added to the system equals that dissipated by the sprays. As the heat load on the pond decreases with time, the sprays dissipate more heat than is being added and the pond temperature begins to decrease.

Drift Loss Model During periods of prolonged spray pond operation without makeup water, it is essential that accurate predictions of water consumption are available. The thermal performance model that was developed is used in conjunction with the system model to predict evaporative losses. An independent model has been developed to predict drift losses. A review of the literature revealed no efforts directly applicable to calculation of drift losses from a spray pond. Due to basic system differences, cooling tower drift measurements cannot be applied directly to spray ponds; therefore, a model was developed from principles of analytical mechanics. The following parameters were included in the model:

1. Drop size spectrum
2. Wind speed and direction
3. Elevation necessary for loss of a drop from the pond
4. Distance of each nozzle from the perimeter of the pond in the direction of drift
5. Pressure drop across the nozzle
6. Angle at which water leaves the nozzle
7. Vertical air entrainment of droplets

Drift is caused by the horizontal drag force exerted on small drops as they move relative to the air. A water drop leaves the nozzle with a certain initial velocity and from that time its motion is determined by drag and gravitational forces. By solving the equations of motion the position of each drop is determined as a function of time. When all initial velocities are considered, the positions of drops of the same size that left the nozzle at the same time trace out a locus in the horizontal plane. When drops of similar size are grouped together a locus results for each drop size group.

The loci are concentric circles for a wind velocity of zero, and are somewhat distorted and translated in the wind direction for nonzero wind speeds.

Once the loci have been determined, for a given wind speed, the fraction of flow lost by drift for each drop size group is the ratio of the length of the locus outside the pond perimeter to the total locus length. Since a locus represents the position of drops of a given group no drops from that group are off the locus at that elevation; consequently, the length of the locus is used to calculate loss fraction rather than the enclosed area. The percentage of flow lost by drift is the sum over the drop size groups of the product of drift loss fraction and flow fraction.

$$P = \sum_{i=l}^{N} F_i B_i$$

Where

P = percentage of flow lost by drift

F_i = fraction of flow in drop size group i that is lost

B_i = fraction of total flow in drop size group i

N = number of drop size groups

In order to facilitate evaluation of the drag coefficient for each drop size group, the drops are assumed to be spherical. High speed photographs show that drops deviate very little from being spherical, especially in smaller diameters that are most important in drift loss considerations.

Since the drag force on a sphere is proportional to the relative velocity raised to a power between 1 and 2 (depending on the Reynold's number), the resulting equations of motion are non-linear. An approximation is made to allow a solution in closed form in which the drag force is assumed to vary linearly over a certain range of velocities. Two velocity ranges are used and for all velocities the approximation equals or exceeds the actual drag force, thus preserving conservatism by maximizing drift losses.

The linear drag force approximation in combination with Newton's Second Law is used to determine the acceleration of a drop and the acceleration is integrated to determine the position of the drop as a function of time. This is done for both the X and Z directions, shown in Fig. 9.2-18 to determine the coordinates, Xi(t,0)' Zi(t,0)' of drop position for the ith drop size group as a function of time and initial direction. The motion in the Y direction is used for calculation of the drop exposure time only.

In order to find the locus of a given drop size group at the elevation necessary for loss from the pond, the time of flight, or exposure time, must be calculated. The motion of a drop in the y-direction, shown in Figure 9.2-18, is used to calculate the exposure time. Since the water leaves the nozzle in a conical pattern, no drag is applied for the first few feet of travel in the vertical direction to allow maximization of the time in the air, which maximizes drift losses. Drag is applied immediately in calculation of X and Z coordinates in order to maximize drift losses. The vertical position, y(t), is determined as a function of time; subsequently, the elevation necessary for loss from the pond is substituted for the position and the resulting implicit equation is solved for exposure time. There is a different exposure time for each drop size group due to the dependence of drag force on drop diameter.

With the exposure time determined, the locus for each drop size group can be generated by considering all initial velocity directions. A computer program has been written to supply the coordinates of points of each locus. The locus in the X, Z plane for each drop size group is integrated numerically over its length to determine the fraction of the locus, and hence the drop size group, that is beyond the perimeter of the pond. The losses for the different drop size groups are summed to determine the total drift loss percentage from the pond.

The percentage of flow loss due to drift is an input parameter for the system model discussed later. The system model uses it as a loss term in determining the water remaining in the spray pond at any time after the start of operation of the sprays. The drift loss for the SSES spray pond is determined as a function of wind speed, and this information is entered as a table, wind speed versus drift loss, in the system program. The drift loss is determined from the table at each time step in the calculation of system parameters.

System Response Model

In order to predict the response of the emergency cooling water system of the SSES design, it was necessary to develop a computer model of the system. Due to the feedback effects of service water temperature on containment response, the model includes the system from the reactor vessel to the spray pond. Of particular interest in the transient analysis of the system is the containment temperature, the service water temperature, and the pond water inventory.

In the computer model the system analyzed is represented by a set of simultaneous differential equations resulting from mass and energy balances written for each element of the system. The following assumptions have been made in writing the equations:

1. The absorption of heat by cooling water system equipment and piping during the transient does not significantly contribute to the system response and is therefore neglected.
2. Saturated conditions are assumed to prevail in the containment and reactor pressure vessel.
3. The RHR heat exchanger effectiveness is calculated using equations from Kays and London (Ref. 5 of Question 371.18) when operating as water-water heat exchangers.
4. Flow rates are assumed to change instantaneously when changed.
5. The ANSI/ANS 5.1 – 1979 decay heat generation methodology is used.
6. The transient analysis is initiated after blowdown at 10 minutes after a LOCA.
7. Complete mixing is assumed where flows are combined in piping.
8. No heat is assumed to be transferred through the containment walls, piping, or spray pond liner.
9. Complete mixing in those elements containing water.

The set of equations that represents the system is solved using a discrete finite differential method. The output of the computer model provides temperatures and water inventories at various points in the system at specified times during the transient analysis. This information is used to plot parameters of interest.

The pond temperature vs. time for the minimum heat transfer case, and pond volume vs. time for the maximum water loss case are shown in Figures 9.2-21 and 9.2-22, respectively.

9.2.7.3.4 Droplet Spectrum Test

Both drift and performance models rely on droplet size input data. A program by the nozzle vendor has been established for measuring the droplet size spectrum from the particular nozzle selected for the system and at the particular nozzle pressure chosen. These measurements are based on established high speed photographic techniques. The test program droplet size spectrum data have been used in the 30 day transient analyses.

9.2.7.3.5 Discussion of Meteorology

The evaluation of spray pond performance as an ultimate heat sink is based on conservative atmospheric conditions. The basis for selection of these conditions is critical due to the sensitivity of performance to variations in wind speed, temperature, and relative humidity. This requires investigation of two somewhat opposing sets of atmospheric conditions: one that would result in maximum water loss (high wind speed resulting in maximum drift loss) and one that would result in minimum heat transfer (low wind speed, high wet bulb temperature, and high

relative humidity). The two sets of conditions have been determined from the available weather data.

The combined effects of wind speed, wet bulb temperature, and dry bulb temperature were considered in selection of the worst time periods. The results of the analyses have been used to synthesize separate 30 day periods of minimum heat transfer and maximum water loss.

Meteorological databases from Avoca Airport near Scranton, PA and from the SSES site were examined to determine these two 30 days periods.

Minimum Heat Transfer Case

The ability of the spray pond to reject heat is dependent on both ambient conditions and water temperature at the sprays. It thus becomes important to evaluate the spray water temperature corresponding to any data point condition before analyzing whether that data point is unfavorable for heat transfer.

The meteorological conditions for the minimum heat transfer case are determined using a coefficient of performance that assigns a relative cooling performance value to each set of coincident meteorological conditions. The coefficient of performance is based on the empirical work of Ranz and Marshall (Ref 1 of Question 371.18) for cooling of water droplets in air.

The meteorological data used for the minimum heat transfer case was selected to comply with Regulatory Guide I.27 Rev. 2. A 30 day period of meteorological data was synthesized by using the worst day, two worst consecutive days, and 27 days of the worst 30 day running average period as selected by a coefficient of performance model. Since the site data for this 30 day period was slightly more severe than that for Avoca Airport, the site data was used for the minimum heat transfer design meteorology. The results are summarized in Table 9.2-9. In addition, the computer model includes solar radiation. The day of the year used to determine the solar input to the Spray Pond was chosen to coincide with the same calendar day as the worst meteorological day.

Maximum Water Loss Case

The major water loss mechanisms that are dependent on meteorology are evaporation and drift loss. A coefficient of water loss was derived based on (a) the work of Ranz and Marshall (Ref 1 of Question 371.18) for evaporation loss and (b) the drift loss versus wind speed curve resulting from the drift model of Subsection 9.2.7.3.3. This coefficient was used to determine the worst 30 day period for water loss. Since the worst 30 day period for water loss from the Avoca Airport was more severe than that from the site, the Avoca data was used for the maximum water loss design meteorology. The results of the analysis for the worst period for water loss are presented in Table 9.2-12. In addition, the Table 9.2-10 data was conservatively combined with the most severe solar radiation conditions during the maximum water loss critical time period.

The maximum water losses are not necessarily coincident with high ambient temperatures. This results from consideration of both drift and evaporative contributions to water loss. Since the object is to establish the adequacy of the water supply during periods of high total water loss, the 30 day period of highest total water loss is considered rather than a period of "high temperature and maximum persistent wind speeds.”

9.2.7.3.6 Discussion of Results

The intent of this discussion is to compare the analytical results of the transient analysis with all other applicable methods of system sizing. Since the analysis has been done to define three separate design parameters (spray array efficiency, drift loss, and system response), this discussion of the results will treat each separately.

Spray Array Efficiency

The spray arrays were tested in July 1983 to demonstrate that measured heat dissipation capability equals or exceeds that which is predicted by analysis. For this test, the spray arrays were operated with a heat load from Unit 1. Ambient conditions were recorded along with the temperature of RHRSW/ESW before and after spraying. Efficiencies were then calculated based on the measured ambient conditions using the thermal performance model and compared to the measured efficiencies.

For wind speeds below 4.5 mph, the measured sprayed water temperature was shown to be lower than the sprayed water temperature predicted by the thermal performance model. This demonstrates conservatism in the low wind speed model. For wind speeds above 4.5 mph, measured sprayed water temperatures were generally higher than those predicted by the model. This indicates that the cooling capability of the spray arrays is less than predicted by the high wind speed model. However, since spray cooling is directly related to spray evaporation, the high wind speed model predicts more evaporation losses than actually occur. The high wind speed model, therefore, is conservative in terms of spray evaporation losses.
For the minimum heat transfer case all wind speeds are set to zero in the calculation of spray efficiencies by the thermal performance model. This is done despite the existence of several data points in the minimum heat transfer design meteorology that have wind speeds above 3 mph. Since the test results indicate that the low wind speed model predicts less heat dissipation than is actually experienced, the exclusive use of this model for the minimum heat transfer analysis is conservative.

For the maximum water loss case, only the high wind speed model is used since all data points in the design meteorology have wind speeds above 3 mph. The sole use of the high wind speed model for the maximum water loss case is conservative since the actual spray evaporation losses are lower than predicted by analysis. The cooling capability of the spray arrays is not a limiting factor in the maximum water loss analysis. Comparison of the conditions measured at Canady's and Rancho Seco Spray Ponds indicated close agreement with the performance predicted analytically (refer to Subsection 9.2.7.6). The analytical results indicate somewhat lesser cooling than was actually measured in both cases and therefore the model provides conservative estimates of spray cooling performance.

A further check on the conservatism of the analytical model has been made by comparing the calculated nozzle performance with other methods that could be found for determining nozzle performance. In every case the model predicted more conservative results (less cooling) than the other methods, and these other methods are not all based on purely theoretical approaches. The Spray Engineering Company, for example, predicts the performance of their nozzles on information obtained from numerous operating installations.

Drift Loss

The drift loss calculations were performed using the Bechtel drift loss program. A typical loss versus wind speed relation is shown in Figure 9.2-15. This represents the total drift loss percentage from a typical spray network at a given spray nozzle pressure. The drift loss program can also calculate the drift loss percentage as a function of nozzle location (nozzle distance from the perimeter of the pond) as shown in Figure 9.2-16 for a typical spray nozzle pressure. There is a rapid increase in drift losses for nozzles near the perimeter as the wind speed exceeds 15 mph. Consequently, the perimeter of the spray pond is designed to be a minimum of 60 feet from the spray nozzles.

The drift loss is calculated for each aligned spray array in the maximum water loss analysis. The results of the analysis show a total drift loss of 5.41 million gallons of water during the 30 day transient, as shown in Table 9.2-8.

Susquehanna drift loss was measured during spray operation and compared to the drift loss as predicted by the drift loss model. Analysis of the drift data collected indicates that drift losses predicted by model are considerably more than measured losses. Drift loss model predictions also compare favorably with data obtained from tests conducted by the University of California at the Rancho Seco spray pond (Ref. 2 of Question 371.18).

System Response

The system response model is a series of mass and heat balance equations representing the transfer processes that exist in the reactor heat removal circuits.

Various cases of the minimum heat transfer analysis for spray pond performances were made assuming different operating modes and component failures. The results of the minimum heat transfer case and the maximum water loss cases are presented in Table 9.2-12. The maximum pond temperature observed during the thirty day minimum heat transfer transient is 97°F. This supports the 97°F ESSW temperature limit since all ESW and RHRSW heat exchangers were analyzed for a 97°F cooling water temperature.

The solar evaporation losses are calculated in a manner similar to that outlined in NUREG 0733. Information on total losses is given in Table 9.2-8.

9.2.7.3.6.1 Thermal Short-Circuiting

Spray pond thermal short-circuiting due to wind blown spray is not considered to be a design problem. The spray nozzles are located at least 60 feet from the intake. Wind has the greatest displacement effect on small droplets. Wind blown spray that may be blown toward the intake has a smaller droplet size spectrum than that for water leaving the nozzle. It should be noted that the heat transfer rate is inversely proportional to droplet diameter. This smaller droplet size spectrum, combined with the winds necessary to produce the drift and the distance the droplets must travel to the intake assures that the small droplets will be cooled with a closer approach to the wet bulb temperature than the large droplets falling near the nozzles. This has been verified by computations using the thermal performance model and the drift model.

9.2.7.3.7 Discussion of Conservatisms Used

In an attempt to ensure the availability and performance of the pond under all circumstances of ambient and cooling duties, the following conservatisms have been employed in the analysis.

9.2.7.3.7.1 Conservatisms in Meteorology

Time Steps in Meteorology

As suggested in Regulatory Guide 1.27, worst day, worst two consecutive days and worst 30 day running average periods are determined and used to synthesize conservative design meteorology.

Magnetic tapes containing 34 years of meteorological observations from Avoca Airport near Scranton, Pa. were obtained from the National Climatic Center operated by the National Oceanographic and Atmospheric Administration in Asheville, North Carolina. The period of record for Avoca data was from January 1, 1949 to December 31, 1982. The data from Avoca Airport was compared to 11 years of data collected on site. The period of record for the site data was from November 1, 1972 to December 5, 1983.

A computer-aided search was done for both databases to determine two periods of time for use as design meteorology. One was chosen such that the ability to cool sprayed water was minimized (minimum heat transfer case). The other was chosen such that the potential for water loss was maximized (maximum water loss case).

The daily average meteorological conditions were computed for the entire period of record for both the Avoca and site data bases. The daily averages were then used to calculate coefficients of performance (COP) and coefficients of water loss (COWL). The COP is a parameter whose value is indicative of the rate of change in temperature of a falling spray droplet, considering convection and heat loss due to evaporation. The COWL is indicative of the water consumption rate, considering evaporative and drift losses. In the calculation of the COP and COWL, coefficients of heat and mass transfer are calculated based on the empirical work of Ranz and Marshall for falling drops. This closely resembles the treatment of falling drops in the calculation of thermal efficiency for the spray arrays.

For the minimum heat transfer case, meteorology is selected such that the most severe meteorology corresponds with the peak pond temperature. The peak pond temperature will occur when the total heat loads on the pond equal the total heat losses. When plant heat loads, solar loads, evaporative losses, conduction/convection losses and sprays heat dissipation are considered, the peak pond temperature occurs on the second or third day of the transient. Therefore, the most severe two or three day period is most important in the selection of design meteorology for the MHT case.

For the minimum heat transfer case, COPs were selected for the following:

- Worst single day
- Worst two consecutive days
- Worst thirty consecutive days

This was done for both the site and Avoca databases. The COPs were then compared. The COPs calculated for the worst single day are identical for the site and Avoca data. For the worst two consecutive days and worst 30 consecutive days, the COPs calculated for the site data are slightly more severe than those from Avoca. Therefore, the meteorology selected from the site data is used for the minimum heat transfer design meteorology. The use of the site data as design meteorology is appropriate, despite its short record, since the search of 34 years of Avoca data did not reveal periods of time when the potential for heat transfer was lower.

The design meteorology as used in the minimum heat transfer analysis utilized the worst single day, worst two consecutive days and 27 synthetic days, each of which is an average of the worst 30 consecutive day period. The design meteorology selected for the MHT case is listed in Table 9.2-9.

For the maximum water loss case, the worst 30 consecutive day average COWL was selected from both the Avoca and site databases. A comparison of the COWLs selected indicates that the Avoca meteorology is more severe than that from the site. Therefore, the use of the Avoca meteorology as the basis for the maximum water loss transient is conservative. The design meteorology selected for the maximum water loss case is listed in Table 9.2-10.

<u>Rainwater Additions</u>

No credit is taken for any rainwater additions to the pond volume over the 30 day transient.

<u>9.2.7.3.7.2 Conservatisms in System Operation</u>

<u>Shutdown Operations</u> The sequence of shutdown operations affects the peak pond temperature during the transient. For at least the first 10 minutes actions are assumed to be fully automatic and outside the operator's control. The subsequent operations are operator actuated.

The peak temperature reached in the pond is dependent on the rate at which the heat is dissipated. As discussed in Section 9.2.7.3.I, the shutdown sequences have been developed to provide a worst case realistic combination of heat loads and flows to the spray pond for both the minimum heat transfer and maximum water loss analysis.

<u>Diesel Operation</u>

The 30 day transient analyses for maximum water loss and minimum heat transfer assume the four aligned diesels are in continuous service for the duration of the transient.

<u>9.2.7.3.7.3 Conservatisms in Models</u>

<u>Drift Loss Model</u>

Drag force for motion in the horizontal direction is assumed to be applied immediately, even though the drop is not formed until it is a few feet from the nozzle.

The time the drop is in the air above the elevation necessary for it to be lost from the pond is calculated on the basis that:

a) The drag force is conservatively estimated so that the time used in the calculation for the drop to fall from its maximum height is longer than it will be in practice.

b) Using the conservatively estimated drag force to calculate the initial velocity at which the spray rises will result in a higher velocity than will actually occur. Consequently the corresponding initial velocity in the horizontal plane, which was used to calculate the drift loss, will also be higher than the actual horizontal velocity. Thus the calculated drift loss, which was used to help determine the capacity of the pond, will be larger than will actually occur.

c) Vertical airflow is included because it increases the time the drop is in the air and hence the time the drop is exposed to horizontal drag forces. The vertical flow model combines the effects of convective airflow and airflow due to entrainment of air in the sprays themselves. The model was verified by comparison with experimental results from the Rancho Seco tests (Ref. 2 of Question 371.18).

The drift loss data collected at Susquehanna and Rancho Seco indicates that the drift loss model is conservative.

Thermal Performance Model

The time the drop is exposed to the air is calculated assuming no drag force. This reduces the overall exposure time, and hence the heat transfer.

System Model

Water loss due to natural evaporation is calculated from a cooling pond model ignoring the spray volume. This increases the natural evaporation loss because the pond area available for natural evaporation loss is greater than it would be if the pond was being sprayed.

Conservative values of all input parameters, such as suppression pool water volume, were used in the calculations made for the system model. Assumption 1 in Paragraph 9.2.7.3.3 is also a conservatism in the system model.

9.2.7.4 Tests and Inspections

The ultimate heat sink will be pre-operationally tested in accordance with the requirements of Chapter 14 as part of tests P14.1, RHR Service Water, and P54.1, Emergency Service Water.

Pre-operational tests will be performed to verify that the controls for the system are functioning properly and that design flows required for operation can be obtained.

A performance test has been performed on the completed pond with heat input from unit one, demonstrating that measured performance equals or exceeds that which is predicted by analysis. (Refer to Subsection 9.2.7.3.6.)

Pipe welds are subjected to heat treating, testing, and inspection in accordance with ASME Section III, Class 3, and the material specification.

The spray system will be tested regularly during normal plant operations in accordance with the requirements of Chapter 16.

9.2.7.5 Instrumentation Applications

Logics and instrumentation are discussed in Subsection 7.3.1.1b and the displays are discussed in Section 7.5. A complete list of the system's process instrumentation is provided in Table 7.5-6.

The bypass and spray header motorized valves in the spray pond system are designed for remote operation from the control room. Loop B operation is also provided from the Unit 1 remote shutdown panel and Loop A operation is also provided from the Unit 2 remote shutdown panel.

The spray pond has temperature indication and alarms for high water temperature and near freezing water temperature.

9.2.7.6 COMPARISON OF SPRAY POND THERMAL PERFORMANCE RESULTS

In order to further demonstrate the conservatism of the spray pond thermal performance model, the model has been applied to a spray pond comparable in size to the one proposed for SSES and on which some performance evaluation tests have been performed. The tests were performed on the spray pond at Canady's Station of South Carolina Electric and Gas Company. In addition to these tests the model has also been applied to a smaller pond with well documented performance, the Rancho Seco Nuclear Power Station of the Sacramento Municipal Utility District. The two sets of test results are discussed separately below.

Canady Station Tests

In order to reduce the temperature rise of the Edisto River due to the Canady Station condenser discharge, a spray pond facility was recently built to lower the temperature of the water returned to the river. The South Carolina Pollution Control Authority required that the river temperature rise not exceed 5°F for all river flow rates. The spray pond was designed to provide the required cooling based on various recommendations. It was found that the expected performance was not realized.

Measurements of wind speed, wind direction, wet bulb and dry bulb temperatures, water temperature before spraying, water temperature just before entering the pond, and pond bulk temperature were taken. The water temperature after spraying was measured just above the surface of the pond at several locations and the average reported. Due to the more extensive instrumentation, the results of the Canady tests must be compared to model predicted values on a point to point basis. The general description of the Canady station spray pond is given in Table 9.2-27. The original design specified that 120,000 gpm were to be cooled from 102°F to 84°F with a coincident wet bulb temperature of 78°F. Subsequently, the design spray flow rate was increased to 180,000 gpm and the cooled water temperature to 88°F. These design conditions proved optimistic.

The results of the comparison of the Canady Station performance with that predicted by the spray pond thermal performance model are presented in Table 9.2-28. The model predictions agree well with the data and are in general more conservative than the measured efficiencies.

Rancho Seco Tests

At the request of the Atomic Energy Commission, the Sacramento Municipal Utility District (SMUD) arranged to have the Rancho Seco spray ponds tested to verify the ability of the ponds to meet the design criteria. SMUD asked the University of California, Berkeley, to perform an experience evaluation of the performance of the ponds. Of particular interest from a performance standpoint was the thermal efficiency of the nozzles and drift loss versus wind speed.

The same parameters recorded in the Canady Station tests were also recorded in the Rancho Seco tests, with the addition of accurate pond level measurements. The Rancho Seco test results are compared with model predicted efficiency values on a point to point basis as was done with the Canady Station tests.

The general description of the Rancho Seco spray ponds (2) is given in Table 9.2-27.

The result of the comparison of the Rancho Seco performance tests and model predictions is given in Table 9.2-29. It can be observed that the model predictions for performance are more conservative that the measured efficiencies.

9.2.8 RAW WATER TREATMENT SYSTEM

9.2.8.1 Design Basis

The raw water treatment has no safety related function and does not convey radioactive materials.

The raw water treatment system is designed to provide filtered and clarified water at an average effluent turbidity of less than 0.3 Nephelometric Turbidity Units (NTUs), 80 to 85 percent of the time, when the equipment is operating at a rate not to exceed 2.0 gpm/sq. ft., and less than 0.5 NTUs when the equipment is operating at a rate not to exceed 4.0 gpm/sq. ft. The filtered and clarified water is furnished to the systems and components listed in Subsection 9.2.8.2.

9.2.8.2 System Description

The Well Water System is the source of domestic water and is the normal source of clarified water. During evolutions which demand more clarified water than the Well Water System is able to supply (e.g. outages, flushing, etc.), the Raw Water Treatment System is placed in service and is the source of clarified water.

The raw water treatment system consists of the following:

a) One sludge recirculating type clarifier

b) One chemical feed system designed to inject alum, coagulant aid, Hypochlorite, and caustic solutions into the clarifier

c) Two gravity filters

d) One clearwell, 15,000 gal capacity

e) Two clearwell pumps, each 100 percent capacity

f) One 500,000 gal capacity clarified water storage tank

g) Three clarified water pumps of 100 gpm, 200 gpm, and 300 gpm capacity

h) One clarifier sludge holdup sump of 10,000 gal capacity with two discharge pumps, each 100 percent capacity

i) One 10,000 gal filter backwash holding tank with two discharge pumps

l) Associated piping and controls for all system operations. The piping is carbon steel for the water lines throughout the system and is rated at 125 psig at 350°F. The chemical inlet lines to the clarifier are stainless steel and polyvinyl chloride (PVC) for corrosion protection.

The system is depicted on Dwgs. M-117, Sh. 1, M-117, Sh. 2, M-117, Sh. 3, M-117, Sh. 4, and M-117, Sh. 5.

The river water turbidity is reduced in the clarifier by the addition of chemicals. Design flow through the clarifier is 300 gpm. During clarifier operation flow rates can range between the minimum required flow rate for the clarifier of 100 gpm and the design flow rate. Clarified water can be bypassed to the Circulating Water System to maintain the minimum clarifier flow rate. The flow rate and pressure of the river water entering the clarifier is controlled by a pressure regulator and a flow control valve. The flow control valve is controlled by the water level in the clearwell.

The clarifier is a positive internal recirculation upflow unit. All chemical addition shall be in proportion to the inlet flow to the clarifier. An inlet flow recorder with totalizer is used to pace the chemical feed utilizing timers. Backflushing and sludge blowdown from the clarifier is automatic and controlled in proportion to inlet flow. The sludge is directed to the clarifier sludge holdup sump for disposal.

The clarified water flows out of the clarifier to the gravity filters. Normally the flow is split between the two filters. However, the system is designed to allow one filter to pass 300 gpm flow while the other filter is backwashing or out for maintenance. An interlock is provided so that only one filter can be backwashed at a time. Backwashing of the filter is initiated by pressure drop or a timer. High pressure across the filters is annunciated. A pushbutton on the panel allows the operator to initiate backwashing of either filter at any time. The backwash flow is routed to the backwash holding tank from where the discharge pumps operated by level switches pump the backwash water back to the clarifier for further settling.

The filtered water flows by gravity to the clearwell. One clearwell pump is in continuous operation which sends the water to the clarified water storage tank. Flow to the storage tank is controlled by a flow control valve on the clarified water tank inlet. A controller throttles the inlet valve in proportion to the clarified water storage tank level. A recirculation line from the clearwell pumps discharge header to the clearwell is provided for protection during low flow demand.

A single header from the clarified water storage tank supplies the clarified water pumps at a positive suction pressure. The 100 gpm capacity pump is in continuous operation to furnish the

expected normal demand of clarified water. If water demands increase, flow switches will start the second and third pump as required to meet the system demands. Flow switches will in turn trip the two additional pumps in sequence as water demands decrease. Minimum flow recirculation lines to the storage tank are provided for each pump discharge line for pump protection. The clarified water pumps can furnish water for the following use during normal operation:

a) Make Up Demineralizer System

b) Clarifier Bearing Seals

d) Circulating Water Biocide Injection Skid for Flushing

e) Circulating Water Pumps Bearing and Seal Cooling

f) Service Water Pump Bearing and Seal Cooling

The well water system provides a backup supply for Circulating and Service Water Pump seal cooling.

The raw water treatment equipment is located in the water treatment building. The clarified water storage tank is located in the yard. The storage tank also acts as the primary water source for fire protection with a standpipe in the tank which reserves 300,000 gal of the stored water for fire protection.

9.2.8.3 Safety Evaluation

Failure of the system will not compromise any safety related system or component or prevent a safe shutdown of the plant.

There is sufficient redundancy and sizing in the raw water treatment system to ensure a sufficient supply of clarified water for plant operating conditions.

9.2.8.4 Testing and Inspection Requirements

Prior to station operation, the raw water treatment system was operated to furnish clarified water to the makeup demineralizer system for startup operations. This use verified that all system components and controls function properly.

Since the raw water treatment system and associated equipment is in daily use, no periodic equipment testing is required. All equipment is accessible for observation where inspection during use will ensure the system's operability.
Sample sinks are provided to periodically collect samples and analyze the clarified water quality.

The system was pre-operationally tested in accordance with the requirements of Chapter 14.

9.2.8.5 Instrumentation Requirements

The raw water treatment system is furnished with a control panel located in the water treatment building which is designed for all remote pushbutton control of the clarification process. Automatic control of the clarification, chemical injection, and filtering of the raw water is included in this system panel.

Flow, turbidity, and pH are all monitored to verify system performance and alarm abnormal conditions.

The clarifier sludge holdup sump is furnished with level switches to indicate high level alarms and to control operation of the discharge pumps. Level switches are also provided on the backwash holding tank for pump control and alarms.

The clarified water storage tank is equipped with level switches to indicate high and low level alarms in the system control panel.

The low level switch also trips the clarified water pumps. Local pressure indicators are provided at the discharge of all pumps in the system for pump head indication.

9.2.9 MAKEUP DEMINERALIZER SYSTEM

9.2.9.1 Design Basis

The makeup demineralizer system has no safety related function and does not convey radioactive materials.

The makeup demineralizer system is designed to provide an adequate supply of demineralized water for the plant operating requirements.

9.2.9.2 System Description

The makeup demineralizer system consists of the following:

a) One makeup demineralizer trailer which may contain cation, anion or mixed bed ion exchangers and an activated carbon filter as provided by the vendor.

b) One demineralized water storage tank of 50,000 gal capacity.

c) One demineralized water jockey pump.

d) Two demineralized water transfer pumps.

e) Two 18,000 gal capacity rubber lined concrete neutralization basins complete with two 100 percent capacity sample pumps and two 100 percent capacity discharge pumps.

f) Associated piping and controls for all demineralizer operations. The piping is primarily stainless steel. The system piping is rated at 85 psig and 100°F.

The complete system is depicted on Dwgs. M-118, Sh. 1, M-118, Sh. 2, and M-118, Sh. 3.

Clarified water or domestic water is supplied to the makeup demineralizer trailer under pressure (see Subsection 9.2.8). The flow rate through the demineralizer trailer is regulated by a control valve located at the inlet to the demineralized water storage tank and is inversely proportional to the tank level.

The activated carbon filter in the makeup demineralizer trailer removes chlorine residual.

When the ion exchange capacity of the trailer is exhausted, the demineralizer trailer is automatically removed from service. If exhaustion is indicated by conductivity or silica analyzers, a manual rinse of the trailer may be performed. If proper quality is not obtained, the trailer is shut down. Alarm annunciation of exhaustion is indicated in the demineralizer system control panel.

The demineralizer trailer is replaced with a regenerated trailer when any of the following criteria are met:

a) The trailer effluent conductivity is ≥0.1 micromho/cm @25°C.
b) The trailer effluent silica is ≥0.01ppm.
c) The trailer rated process volume has been reached.

The neutralization basins collect the trailer rinse water, in addition to chemical wastes pumped from the chemical waste sumps in the water treatment building (circ. water pumphouse). All equipment and process drains on the west side of the water treatment building are routed to the chemical waste sump. All equipment and process drains on the east side of the water treatment building are routed to the water treatment building sumps. All discharges from the neutralization basins are conducted in accordance with the station's NPDES permit.

The demineralized water flows to the 50,000 gal capacity storage tank. Prior to unit operation, demineralized water was used to fill the condensate and refueling water storage tanks, and to fill and flush systems. During normal operation, the demineralized water is used for services such as:

- Various service connections throughout the Reactor, Turbine, Radwaste and Control Buildings, the Drywell and the S&A Building Maintenance Shop
- Reactor and Turbine Building Sample Stations
- Chilled water systems and closed cooling water systems makeup
- CRD Test Pump
- RHR heat exchanger flushing
- Diesel generator jacket cooling water makeup
- Refueling water and condensate water storage tank makeup
- Condenser Hotwell makeup
- Standby liquid control system makeup
- Condensate Filtration System iron injection skid
- Condensate Filtration System polymer and chemical injection skids
- Mobile Radwaste Processing
- Source of water to a tank that provides a passive, backup keepfill function to the ECCS and RCIC pump discharge lines. The tank will be maintained filled with at least 2,000 gallons of water.

A single header from the demineralized water storage tank supplies the demineralized water jockey pump and transfer pumps at a positive suction pressure. The jockey pump is in

continuous operation and is controlled by an on-off hand switch. A recirculation line back to the demineralized water storage tank is provided for prevention of pump overheating on low system demands. The two transfer pumps are controlled by on-off-auto hand switches. During normal operation one transfer pump is in the auto position and the other is in the off position. Low pressure on the pumps discharge header will start the transfer pump in the auto position. This pump will stop when a set high pressure is reached. The second transfer pump can be started manually at any time. Recirculation lines are provided for pump protection. A low-low level switch on the demineralized water storage tank will stop the jockey and transfer pumps.

The makeup demineralizer trailer is located outside the Circulating Water Pumphouse and the associated equipment is in the Circulating Water Pumphouse. The demineralized water storage tank is in the yard and is furnished with an electric heater to prevent freezing.

9.2.9.3 Safety Evaluation

Failure of the system will not compromise any safety related system or component or prevent a safe shutdown of the plant.

9.2.9.4 Testing and Inspection Requirements

Since the makeup demineralizer system is in weekly use, no periodic equipment testing is required. All equipment is accessible for observation where inspection during use will ensure the system's operability.

Grab samples from the Demineralized Water Storage Tank are periodically tested to verify demineralizer performance. Trailer effluent samples are tested when a trailer is first placed in service and when alarms are received.

9.2.9.5 Instrumentation Requirements

The makeup demineralizer system is furnished with a control panel, located in the Circulating Water Pumphouse.

The demineralizer trailer effluent is monitored by in-line conductivity and silica monitors. The monitors will alarm and automatically isolate the trailer if their setpoint is exceeded. A flow totalizer is located at the trailer influent.

The neutralization basins are furnished with level switches to indicate high and low level alarms and to control the operation of the sample and discharge pumps.

The demineralized water storage tank is equipped with a level switch that alarms in the main control room to indicate demineralized low water level. This switch also trips the demineralized water jockey and transfer pumps. Local pressure indicators are provided at the discharge of all pumps in the system for pump head indication.

9.2.10 CONDENSATE STORAGE AND TRANSFER SYSTEM

9.2.10.1 Design Bases

The condensate and refueling water storage system has no safety related function and is designed to perform the following functions:

a) Supply water to fill the reactor well and dryer-separator pool of one unit during refueling operations and to provide storage for this water when refueling is completed.

b) Supply condensate for various processes in the radwaste system and makeup for the Plant systems including the condenser hotwells.

c) Supply condensate to the suctions of the HPCI, RCIC, Core Spray and CRD Pumps associated with Units 1 and 2

d) Provide a minimum storage capacity of 135,000 gal for the RCIC and HPCI Pumps associated with each unit

e) Provide the capability to demineralize the water in the refueling water storage tank by pumping it through the condensate demineralizers and returning it to the storage tank

f) Provide storage for condensate rejected from the cycle

g) Provide storage for condensate returned from the radwaste system

h) Provide the capability to drain the reactor well through the condensate demineralizer and back to the storage tank.

i) Provide the capability for HPCI and RCIC to recycle water during the test mode.

j) Provide a supply to the "keep filled" system for core spray, RHR, HPCI and RCIC pump discharge lines. A backup keepfill function is provided by the Demineralized Water System (Refer to FSAR Section 9.2.9).

k) Supply condensate to the fuel pool as make-up for evaporative losses.

l) Supply condensate for condensate filter vessel fill and for CFS backwash receiving tank, transfer pump, and piping flush.

9.2.10.2 System Description

The condensate storage system is shown in Dwg. M-108, Sh. 1. The various flow paths are listed in Table 9.2-11, which also includes the operating modes to achieve these flow paths.

The system consists of the following:

a) One atmospheric condensate storage tank for each unit, each with a capacity of 300,000 gal

b) Two horizontal centrifugal condensate transfer pumps, each full capacity, and rated at 600 gpm

c) One atmospheric refueling water storage tank with a capacity of 680,000 gal, common to both units

d) Two horizontal centrifugal refueling water pumps, each full capacity, and rated at 1500 gpm

e) Interconnecting piping, valves, instruments and controls.

Condensate Storage Tanks (Units 1 and 2)

These tanks are the preferred source of water for the HPCI and RCIC pumps for both operational use and testing. In addition, they supply water to the core spray pumps which is used for testing.

The condensate transfer pumps also take their suction from these tanks to provide water for various services in the radwaste building, the reactor building, and for backwashing the cleanup filter demineralizers and the fuel pool filter demineralizer.

Each condensate transfer pump is rated at 100 percent capacity; normally only one runs at a time. If the discharge pressure of the operating pump falls, the second pump will start automatically. Both pumps can be operated in parallel. Each pump is controlled from the main control room.

Each condensate storage tank maintains a minimum storage of 135,000 gallons to service the associated HPCI and RCIC Pumps during plant operation by use of standpipes and locked closed valves on all other lines.

Makeup is supplied by the demineralized water transfer pumps.

The tanks also act as surge tanks for the condensate systems by receiving any rejected condensate from and making up any deficiency in the heat cycle under the action of the level controls on the condenser hotwell.

Refueling Water Storage Tank

The refueling water storage tank stores the water that is used to fill the reactor well and dryer-separator pool of either Unit 1 or 2.

During refueling operations water inventory is transferred from the storage tank to the respective reactor well and dryer-separator pool. The refueling water pumps are started and stopped manually to support this evolution. Each pump can be controlled from either the main control room or from the refueling floor thus permitting an operator at either of these locations to operate the pumps. During refueling fill evolutions, both pumps are typically run in parallel.

When refueling is complete the water in the reactor well and dryer-separator pool can be emptied to the refueling water storage tank through a condensate filter-demineralizer. Makeup for the refueling water storage tank is supplied by the demineralized water transfer pumps taking suction from the demineralized water storage tank.

The refueling water storage tank also provides water to fill the spent fuel cask storage pool. This water can be returned to the tank through the condensate filter demineralizer.

During plant shutdown when there is no condenser vacuum, up to 1000 gpm of water is provided to the primary coolant degasifier system for deaeration. The deaerated water is returned back to the refueling and condensate storage tanks.

9.2.10.3 Safety Evaluation

The Unit 1 condensate storage tank and the refueling water storage tank are located outdoors. The area occupied by the two tanks is surrounded by walls designed to retain the total volume of water contained in both the refueling water storage tank and the Unit 1 condensate storage tank if both tanks rupture simultaneously. The Unit 2 condensate storage tank, also located outdoors, is surrounded by a wall designed to retain the total volume of water in the tank if it ruptures.

Water that collects within the retaining walls can be processed to the liquid radwaste system, discharged to the cooling tower blowdown outfall via a tanker or drained directly to the storm sewer. Berm area water discharged to plant outfalls is sampled for radiation and water quality prior to release.

9.2.10.4 Tests and Inspections

The condensate storage and transfer system is used during Plant operation and requires only visual inspections for leakage or deterioration and to verify operation of the various transfer pumps.

The system was pre-operationally tested in accordance with the requirements of Chapter 14.

9.2.10.5 Instrumentation Applications

Condensate Storage Tanks

Each tank is provided with a level transmitter that operates a pen in a recorder located in the control room. Each condensate storage tank has a separate pen. In addition to the level transmitters, each tank has high and low level switches that alarm in the control room and a low level switch that trips the condensate transfer pumps if they are running.

Redundant low and low-low level switches are installed in each tank to provide a permissive to allow the RCIC and HPCI pumps to take suction from the respective reactor suppression pool instead of from the respective condensate storage tank, which is the primary source of water to the HPCI and RCIC systems. A detailed description of the condensate Transfer Pump discharge low pressure alarm and its function with regard to the ECCS/RCIC pump discharge keep filled system is provided in Section 6.3.2.2.5.

Refueling Water Storage Tank

This tank is provided with a level transmitter that operates a third pen on the control room recorder referred to above. In addition the tank has high and low level switches which alarm in the control room and a low level switch that trips the refueling water pumps if they are running.

9.2.11 POTABLE WATER AND SANITARY WASTE SYSTEMS

The potable water system, (a.k.a the domestic water system) is a groundwater-supplied (a.k.a well water) system that provides cold and hot water throughout the station. The domestic water system also serves as the primary source of water for the Clarified Water System (described in Section 9.2.8.2). The back-up water source for the clarified water system is river water via the station's Reactivator. Domestic water for potable uses has no backup.

The sanitary waste system (a.k.a the Sanitary Waste Treatment System) treats and disposes of waste water from all the station plumbing fixtures except those which could possibly contain chemicals. Note that waste water discharges are managed in compliance with the station's National Pollutant Discharge Elimination System (NPDES) permit.

9.2.11.1 Design Bases

The domestic water system has no safety related function and is designed to prevent radioactive contamination of this system. Before well water enters the station's domestic water distribution system, it is filtered and treated in order to ensure the water is safe to drink. This treatment is described in Subsection 9.2.11.2.3.

With a 500,000 gal Well Water Storage Tank (0T594) the domestic water system is designed to provide up to a maximum of 200 gpm during peak demand periods.

Water heaters are provided to supply hot water to the toilet and shower areas and other locations where needed. The storage capacities of the water heaters are based on the maximum hot water demand which is anticipated to occur during the plant personnel shift change during maintenance and refueling operations.

9.2.11.2 System Description

The domestic water system is supplied from two wells (TW-2 and TW-1), and both wells are located within the same aquifer. Of the two wells, TW-2 has the highest recharge rate, hence serves as the system's primary supply well. TW-1, which has a significantly lower recharge rate, serves as the system's back-up well. The well water system design does not allow groundwater withdrawal from TW-2 and TW-1 simultaneously.

Drinking water treatment is described in Subsection 9.2.11.2.3.

The domestic water system is designated as non-Seismic Category I. (The only exception is that piping inside the Diesel Generator 'E' Building was analyzed to Seismic Category I requirements.) The domestic water system includes the components necessary to draw, treat, and dispense finished potable water for personnel consumption and for use in plant systems.

The domestic water system is shown in Dwgs. M-117, Sh. 3, M-117, Sh. 4, and M-117, Sh. 5.

9.2.11.2.1 Well Water Storage Tank (0T594)

The Well Water Storage Tank (0T594) is a carbon steel tank with a nominal storage capacity of 500,000 gallons. This tank provides the necessary disinfection contact time for the treated well water, and serves as the direct water supply for the domestic water distribution system and the

clarified water system and has 180,000 gallons of the tank's nominal storage capacity in reserve for the fire protection water system.

9.2.11.2.2 Domestic Water Jockey Pumps

Two domestic water jockey pumps supply treated (finished) well water to the station via the domestic water distribution system. Normally one pump is in continuous operation, with the second pump on automatic standby. The standby pump starts automatically when the header pressure decreases. The standby pump will stop automatically when reduced demands cause the system pressure to rise.

9.2.11.2.3 Domestic Water Treatment

Sodium hypochlorite is injected into the well water to: (1) disinfect the well water, and (2) oxidize soluble iron to render it insoluble prior to entering the Green Sand Filter (0F805). As the chlorinated well water passes through the green sand filter, any insoluble iron in the well water is filtered/removed. Additionally, a pH additive is injected into the well water in order to reduce copper and lead levels.

Following this direct treatment, the well water is stored inside a 500,000 gallon capacity Well Water Storage Tank (0T594) to ensure the well water receives adequate contact time with chlorine prior to entering the Domestic Water Distribution System.

9.2.11.2.4 Green Sand Filter

The green sand filter (0F805) removes the insoluble iron through the use of filter media.

9.2.11.2.5 Hot Water Storage Heaters

Electric storage domestic water heaters are provided in various buildings, where there is a requirement for domestic hot water, such as the Control Structure, the Service and Administration Building, the Radwaste Building, the North Gatehouse, the Circ. Water Pump House, the Security Control Center, the South Gatehouse, the South Building, the North Building, and the Warehouse. As required depending on the application, the pressure tanks of certain water heaters are constructed and stamped in accordance with the applicable ASME Code Section IV. All water heaters are wired in accordance with the National Electric Code and are UL listed.

9.2.11.2.6 Valves

ASME code-rated and approved relief valves are provided on all electric storage water heaters for temperature and pressure relief.

Self-actuated pressure reducing regulators are provided in the branch lines supplying each building. Pressures are set to ensure that no plumbing fixture or equipment connection is subjected to a static pressure greater than 65 psig or less than 15 psig.

9.2.11.2.7 Piping

Piping materials used in the potable water distribution system will prevent the introduction of objectionable tastes, odors, discoloration and toxic conditions into the system, and conform to the provisions of the Uniform Plumbing Code.

Piping sizes were designed to limit the flow velocity to a maximum of 8 fps and thus minimize noise, system shock and water hammer. Water hammer arresters, approved and certified by the Plumbing and Drainage Institute, are installed at appropriate locations.

9.2.11.2.8 Sanitary Waste Disposal

All wastes from plumbing fixtures that have no potential for radioactive, oil or chemical contamination are conveyed to the station's Sewage Treatment Plant.

The sewage treatment plant combines, pulverizes, and aerates the influent sewage and then clarifies it by settling the sludge. The treatment plant then removes the sludge and disinfects the effluent that discharges to the Susquehanna River. The effluent water quality from the Sewage Treatment Plant is managed in compliance with the station's NPDES permit.

The sewage treatment system is shown schematically in Figure 9.2-10.

9.2.11.3 Safety Evaluation

The Domestic Water and Sanitary Waste Treatment Systems are not safety-related and are not designed to Seismic Category I requirements, with the exception of piping inside the Diesel Generator 'E' Building which was analyzed to Seismic Category I requirements. Failure of this system will not compromise any safety-related system or component or prevent safe shutdown of the plant.

Contamination of the potable water system will be prevented by a combination of air gaps, vacuum breakers and backflow preventers of the reduced pressure zone type or double check valve assembly type.

The chlorination units which were used to treat clarified water when it was used as plant potable water have been taken out of service. Therefore, backflow preventers are installed on the clarified water/well water crosstie line to prevent untreated clarified water from entering the potable water.

Backflow preventers are provided on both the 1-1/2 in. hot and 2 in. cold water branch lines supplying the Laundry Room and the 1 in. hot and cold water branch lines supplying the Radiation Chemical Laboratory in the Control Structure.

The 2-in. cold water lines that will supply water to the decontamination showers and lavatories in Units 1 and Unit 2 Reactor Buildings are provided with backflow preventers before they enter the buildings.

Backflow preventers are also provided on the 1-1/2 in. hot and cold water lines that will supply water to the decontamination showers and lavatories, clothes washers, service sink and the flushing nozzles of the Radwaste Solidification System in the Radwaste Building.

Decontamination lavatories are provided with faucets that are photocell actuated to automatically close whenever the hands are removed and/or with foot-operated faucets. The spout location provides an air gap of 6-1/2-in. from the flood level. All hose bibb connections to the clothes washers are provided with vacuum breakers. All sink faucets with hose connections are also provided with vacuum breakers. The flushing spray nozzles for the radwaste solidification system discharge to atmospheric pressure and are controlled by normally closed, fail closed valves in addition to the 1-1/2-in. backflow preventer.

Sanitary waste is disposed of in accordance with the requirements of the Pennsylvania Department of Environmental Protection. Potentially contaminated waste from the decontamination showers and lavatories, laundry room, and chemical laboratory is directed to the radwaste treatment system.

9.2.11.4 Tests and Inspections

The potable water piping was subjected to a hydrostatic test pressure of 100 psig. The system was disinfected with 50 ppm chlorine for 24 hours. The system was then drained and flushed with potable water. The sanitary waste piping was subjected to a hydrostatic test pressure of not less than a ten-foot head of water.

Inspection of the entire system for compliance with the provisions of the Uniform Plumbing Code was performed.
Periodic tests on the potable water were performed to determine the residual ppm chlorine content. The sanitary waste is tested periodically to determine the settable solids and pH of the effluent and the dissolved oxygen at the beds.

The system was preoperationally tested in accordance with the requirements of Chapter 14.

9.2.11.5 Instrumentation Application

Pressure controllers are provided to start and stop the domestic water Jockey pumps as described in Subsection 9.2.11.2.2. Thermostats, high-temperature limit switches, and temperature gauges are installed on hot water storage heaters. Alarm units, activated upon operation of emergency showers and eyewash units, register local alarms.

A flow meter measures, records and totalizes the effluent flow of the sewer system. An electrical control panel with on-off pushbuttons and indicator lights for all blower motors, surge tank pump, spray pumps, chlorinator and all other motors of the sewage treatment plant is installed in the sewage treatment control house. Trouble alarm for any motor failure in the treatment plant, including trouble with the motor or compressor of the surge tank effluent pump, and the air pressure shall be transmitted to the main plant control room with local indication of the particular malfunction.

9.2.12 CHILLED WATER SYSTEMS

9.2.12.1 Control Structure Chilled Water System

9.2.12.1.1 Design Bases

The control structure chilled water system is designed to supply chilled water at 44°F to the control room floor cooling system, computer room floor cooling system, and the control structure H&V system. These systems maintain design air temperatures inside the control structure during all modes of plant operation.

The control structure chilled water system also supplies chilled water to the Unit 1 reactor building emergency switchgear room air handling system emergency cooling coils during normal operation, a loss of coolant accident, a loss of offsite power and, when temperature rises above 102°F in the emergency switchgear room (initiated by temperature switch). The control structure chilled water system is designed so that a single failure of any active component, assuming loss of both offsite power and normal source of cooling water, cannot result in loss of chilled water to the above air conditioning systems during all modes of plant operation.

Codes and standards applicable for the system are listed in Table 3.2-1.

The control structure chilled water system has three subsystems.

a) The chilled water circulation subsystem is safety related and designed to meet Seismic Category I requirements.

   The pressure vessels, piping, pumps, valves, and tanks in this subsystem are designed to quality group D, in accordance with Safety Guide 26, March 1972.
   The system was not designed to quality group C (ASME Section III, Class 3), since the purchase orders for the main components (centrifugal chillers and air handling units) were placed in May and July 1974. Regulatory Guide 1.26 (September 1974), provides an option to design the control room chilled water system to quality group D for the plants whose docket date of application precedes January 1, 1975. Since the system is Q-listed and Seismic Category I, the design meets Regulatory Guide 1.26 with the above exception.

b) The emergency condenser cooling water subsystem.

   This subsystem has a safety related function and is designed to meet Seismic Category I requirements.

   The pressure vessels, piping, pumps, and valves in this subsystem are designed to quality group C (ASME Section III, Class 3) to comply with the design basis of the emergency service water system.

c) The normal condenser cooling water subsystem.

   This subsystem has no safety related function and is not Seismic Category I.

   The pressure vessels, piping, pumps, and valves in the subsystem are designed to quality group D in accordance with Safety Guide 26, March 1972.

9.2.12.1.2 System Description

9.2.12.1.2.1 General Description

The system is common to Units 1 and 2. The system consists of two identical 100 percent capacity chilled water trains. Each train consists of a centrifugal chiller, a chilled water pump, one normal condenser water pump, one emergency condenser water pump, seven cooling coils, closed expansion tank, chemical addition tank, air separator, interconnecting piping, valves instrumentation, and controls. The system is shown schematically on Dwgs. M-186, Sh. 1, M-186, Sh. 2 and M-111, Sh. 2. Dwgs. M-186, Sh. 1 and M-186, Sh. 2 show the 'A' Control Structure Chilled Water subsystem. The 'B' subsystem is similar.

Heat from the seven space cooling coils is transferred to the chiller by the circulating chilled water. The heat gained is removed from the chilled water in the chiller evaporator, by a flow of refrigerant which in turn is cooled by the condenser cooling water.

During normal plant operation the source of condenser cooling water is the non-safety related service water system. Whenever emergency conditions prevail, the safety related Emergency Service Water System (ESWS) provides condenser cooling water.

The normal makeup water supply to the chilled water circulation system is through the manually controlled valve provided in the makeup demineralized water system. The ESWS provides a redundant source of makeup water through a manual control valve.

The chemical addition subsystem, provided to minimize piping corrosion and scale buildup, is manually controlled and is normally isolated. This subsystem is not safety related. The components of the system are located in the control structure building.

An air separator and an expansion tank are provided to accommodate expansion and contraction in the system due to temperature fluctuations.

9.2.12.1.2.2 Component Description

Design data for major components of the control structure chilled water system are listed in Table 9.2-14.

9.2.12.1.2.3 System Operation

One of the two chilled water trains will be in operation during all modes of plant operation including LOCA. Starting a chilled water pump from the control room initiates the operation of that train. Under normal conditions, one chilled water train will be operating and the other train will be on standby.

Chilled water outlet temperature will be maintained at 44°F by automatically positioning the compressor inlet vanes that are controlled by the temperature of the chilled water line leaving the evaporator.

Each of the air handling systems is provided with a thermostatically controlled chilled water three way valve modulated by a temperature controller to match the cooling load requirement. Operation of the standby control structure chilled water train will be automatic on failure of the operating train.

The control structure chilled water system is powered from the emergency power supply system. On loss of offsite power the lead chilled water train will restart automatically according to the diesel generator loading sequence. The chiller is capable of restarting approximately 4-1/2 minutes after power is restored.

If the water level in the closed expansion tank falls below the low level, this condition will be annunciated in the control room.

In the event of a control room evacuation manual control of the 'A' train can be taken at the Control Structure HVAC Alternate Control Panel. At this panel, the 'A' train chiller, the chilled water circulating pump, the chilled water emergency condenser water circulating pump, and the ESW supply valve can be manually operated. Operation from this panel provides input to the Bypass Indication System.

9.2.12.1.3 Safety Evaluation

The control structure chilled water system is housed within the Seismic Category I control structure. Wind and tornado protection is discussed in Section 3.3. Flood design is discussed in 3.4. Missile protection is discussed in Section 3.5. Protection against dynamic effects associated with the postulated rupture of piping is discussed in Section 3.6. Environmental design considerations are discussed in Section 3.11.

The components of the system required for emergency operation are designed to Seismic Category I requirements. The components and supporting structures that are not Seismic Category I, and whose collapse could result in a loss of a required function of the chilled water system through either impact or flooding, are analytically checked to verify that they will not collapse when subject to seismic loading from the Safe Shutdown Earthquake.

Adequate chilled water system capacity was selected to allow the air conditioning system to maintain design ambient air temperatures inside the control structure building, and the system is tested to ensure adequate capacity. In addition, the chilled water system capacity is adequate to provide cooling to the ESF - SWGR air handling units during a LOOP and LOCA condition.

Two separate 100 percent capacity independent systems provide mechanical redundancy. This, together with the redundancy of electrical design, ensures that a failure of any single active component cannot result in a loss of both trains of engineered safety feature chilled water. Therefore, cooling is assured for the equipment needed to safely shut down the plant.

For a failure mode and effect analysis of the Control Structure chilled water system, refer to Table 9.2-15.

9.2.12.1.4 Tests and Inspection

The system was preoperationally tested in accordance with the requirements of Chapter 14.

Provision is made for periodic inspection of major components to ensure the capability and integrity of the system. Local display devices are provided to indicate pressures and temperatures for tests and inspections. During normal plant operation, when the Emergency Service Water System is available, the emergency condenser water pump of the operating chiller can be test operated. A test switch located in the control room can simultaneously stop

the normal condenser water pump and start the emergency condenser water pump without stopping the chiller.

9.2.12.1.5 Instrument Applications

The hand control switches of the chilled water pumps and the status indicating lights of the major components of the chilled water systems are located in the control room. A chilled water train is started or set in a standby mode through the control switch of the chilled water pump.

Hand control switches for the chilled water circulating pump, the emergency condenser circulating pump, the chiller, and the Emergency Service Water control valve are located on the Control Structure HVAC Alternate Control Panel along with their respective status indicating lights. Manual operation from this panel isolates control from the control room.

The chilled water system instrumentation is redundant and seismically qualified. Power supplies to the instruments are redundant and connected to the emergency buses.

Indicators for the chilled water temperature and flow as well as the emergency condenser water flow are provided in the control room and will monitor the operation of the chilled water loop during emergency conditions.

The following abnormal conditions are alarmed in the control room:

a) Failure of the chilled water pump/loss of FSL-08621A/B control power.

b) Failure of the normal condenser water pump.

c) Failure of the emergency condenser water pump.

d) High and low water levels at the expansion tank.

e) Chilled water high temperature.

f) CSHVAC alternate control switches in emergency position.

9.2.12.2 Turbine Building Chilled Water System

9.2.12.2.1 Design Bases

The turbine building chilled water system has no safety related function.

During normal operation the turbine building chilled water system is designed to supply chilled water for maintaining design ambient air temperatures in various areas throughout the turbine building. The system is designed to permit periodic inspection, testing, and maintenance of principal components with a minimum loss of normal operation.

Codes and standards applicable for the system are listed in Table 3.2-1.

9.2.12.2.2 System Description

9.2.12.2.2.1 General Description

Unit 1 turbine building chilled water system supplies chilled water to supply unit cooling coils, recirculation unit cooling coils, condensate pump room unit coolers, condenser compartment unit coolers, and access control unit cooling coils. The Unit 2 system is identical except that the access control cooling load is met by the Unit 1 system. Units 1 and 2 systems also provide chilled water to their respective mechanical vacuum pump seal water coolers during startup. The following is a description of the Unit 1 system.

The system consists of two centrifugal water chillers, two evaporator chilled water circulating pumps, two condenser water circulating pumps, two chilled water loop circulating pumps, an air separator, an expansion tank, a chemical addition tank, air cooling coils, interconnecting piping, instrumentation and controls. One chilled water loop circulating pump, one evaporator chilled water circulating pump, one condenser water circulating pump, and one chiller normally operate, while the others remain on automatic standby. However, if the cooling load exceeds the full capacity of one chiller, the standby chiller will automatically pick up a portion of the load.

The system is shown schematically on Dwg. M-188, Sh. 1.

Heat gained by the circulating chilled water is removed in the chiller evaporator by a flow of refrigerant which in turn is cooled by the condenser cooling water.

Condenser cooling water is provided by the service water system.

The makeup water supply to the Turbine Building Chilled Water System is through the manual valve provided in the makeup connection from the demineralized water system.

The chemical addition subsystem provided to minimize piping corrosion and scale buildup is manually controlled.

An air separator and an expansion tank are provided to accommodate expansion and contraction in the system due to temperature change.

The components of the system are located in the turbine building.

9.2.12.2.2.2 Component Description

Design data for major components of the turbine building chilled water system are listed in Table 9.2-16.

9.2.12.2.2.3 System Operation

The Turbine Building Chilled Water System operates on a year-round basis. Chilled water is circulated through the supply loop to the air cooling coils. The return chilled water is cooled by the chiller and recirculated.

One chilled water loop circulating pump and one chiller, with its associated evaporator water circulating pump and condenser water circulating pump (a “chiller loop”), normally operate. The other chilled water loop circulating pump and the other chiller loop are normally placed in

automatic standby. Either chiller loop may be operated with either chilled water loop circulating pump.

The system is manually started from local panels by starting a selected chilled water loop circulating pump, then an evaporator water circulating pump, which also starts the corresponding condenser water circulating pump, and then the corresponding chiller.

The standby chilled water loop circulating pump will automatically start if the operating pump fails.

The standby chiller loop will automatically start if the operating chiller loop cannot meet demand. If the chilled water return temperature exceeds its setpoint, either because the cooling load exceeds the capacity of the operating chiller or because the operating chiller fails, or if the operating chiller or a circulating pump fails, the standby chiller loop components automatically start, to pick up the load.

Two temperature sensors located downstream of the chillers in the chilled water supply main modulate the compressor inlet guide vanes of their respective chillers to maintain a constant chilled water supply temperature in the loop.

The chiller condensor cooling water outlet temperature is maintained constant by mixing the cooling water supply and return flow using two butterfly valves under the control of the Condenser Leaving Water Temperature Controller.

Three way mixing valves regulate chilled water flow rate through the supply unit cooling coils, recirculation unit cooling coils, and access control H/V unit cooling coils.

When the temperature of air upstream of any of the cooling coils in the turbine building supply unit or access control H/V unit drops below the set value of the temperature switches, this is annunciated locally as indication of failure of the upstream heating coil. Further drop of air temperature in the Access Control H/V Unit will be detected by another temperature switch which will isolate chilled water to the unit cooling coils and open drain valves to prevent freezing. A vacuum breaker provides automatic venting for this automatic drain function. Manual isolation, vent, and drain valves, and demineralized water connections, permit manual isolation, drain, and fill of the Turbine Building Supply Unit Cooling Coils and of the Access Control H/V Unit Cooling Coils; or refill of the Access Control H/V Unit Cooling Coils after an automatic drain for freeze protection. Isolation, vent and drain valves permit drain and fill of unit coils, and of sections of the remainder of the Turbine Building Chilled Water System. Manual switches and valves are provided to permit coil drain system testing, if required.

High and low levels of the expansion tank are annunciated locally and retransmitted as a trouble alarm to the control room. The tank is filled, drained, and pressurized through manual valves.

9.2.12.2.3 Safety Evaluation

Since the turbine building chilled water system has no safety design basis, no safety evaluation is provided. However the system includes some features that ensure its reliable operation during normal plant operation. These features include redundant components for equipment such as chillers and pumps.

9.2.12.2.4 Test and Inspections

The system was preoperationally tested in accordance with the requirements of Chapter 14.

Provision is made for periodic inspection of major components to ensure the capability and integrity of the system. Local display devices are provided to indicate pressures and temperatures for tests and inspections.

9.2.12.2.5 Instrument Applications

Operation of the water chillers and chilled water pumps will be initiated manually from local control panels. Automatic standby operation of chillers and pumps is provided.

Indicators on the local panel provide operation status of chillers and pumps. Local indicators display pressures and temperatures required to monitor operation of the chillers and pumps.

The following abnormal conditions are alarmed at the local control panel and retransmitted to the control room as a trouble alarm:

a) Failure of any pump

b) Failure of any chiller

c) High and low water level in the expansion tank

d) Low temperature at the upstream face of the cooling coil in the access control heating/ventilating unit and turbine building supply unit.

9.2.12.3 Reactor Building Chilled Water System

9.2.12.3.1 Design Bases

Portions of the Reactor Building Chilled Water System have safety related functions. The safety related portions include the primary containment piping penetrations and containment isolation valves. The safety related portions are designed to meet Seismic Category I requirements.

The chilled water piping inside the drywell is supported to ensure that it will have no adverse effects on adjacent safety related equipment in the event of an earthquake.

During normal operation the Reactor Building Chilled Water System is designed to maintain normal design air temperatures in various areas in the reactor building, including the emergency switchgear and load center room and the drywell.

The system is also designed to supply chilled water to the reactor recirculation pump motor coolers inside the drywell to maintain motor temperature within allowable limits.

The Reactor Building Chilled Water System is designed to permit periodic inspection, testing, and maintenance of principal components with a minimum loss of normal operation.

The Reactor Building Closed Cooling Water System provides a backup to the portion of the Reactor Building Chilled Water System that serves the primary containment, to maintain drywell

temperatures and provide reduced cooling to the recirculation pump motor coolers during loss of offsite power or failure of the Reactor Building Chilled Water System.

Codes and standards applicable for the System are listed in Table 3.2-1.

9.2.12.3.2 System Description

9.2.12.3.2.1 General Description

Unit 1 Reactor Building Chilled Water System supplies chilled water at approximately 50°F to the Zones I and III air supply unit cooling coils, emergency switchgear and load center room air handling units, reactor recirculation pump motor coolers, and drywell unit coolers. The Unit 2 system is identical except that Zone I (Unit 1 portion of the cooling load) is replaced by Zone II for Unit 2.

The following discussion is applicable for the Unit 1 system.

The system consists of two centrifugal water chillers, two evaporator chilled water circulating pumps, two condenser water pumps, two chilled water loop circulating pumps, an air separator, an expansion tank, a chemical addition tank, air-cooling coils, interconnecting piping, instrumentation, and controls. Each of the chillers and pumps is sized for 100 percent of system capacity.

The system is shown schematically on Dwgs. M-187, Sh. 1 and M-187, Sh. 2.

Heat gained by the circulating chilled water is removed in the chiller evaporator by a flow of refrigerant, which in turn is cooled by the condenser cooling water.

Cooling water to the chiller condensers is provided from the plant Service Water System. Makeup water supply is through a manual valve provided in the branch connection from the demineralized water supply system.

The chemical addition subsystem, provided to minimize piping corrosion and scale buildup, is manually controlled and is not safety related.

An air separator and an expansion tank are provided to accommodate expansion and contraction in the system due to variations in temperature. The components of the system are located in the reactor building.

During plant outages the heat load on the Reactor Building Chilled Water System is greatly reduced. If the Reactor Building Chillers remain in service, they may experience cycling due to the reduced load. To prevent this cycling, a temporary outage chiller system may be installed and operated, thereby allowing the Reactor Building Chillers to be shutdown. The temporary equipment is sized for the lower heat loads present during outage conditions. The temporary outage chiller system will be connected to the Reactor Building Chilled Water System return header in such a manner as to supply chilled water to all the normal Reactor Building Chilled Water System loads. The temporary outage chiller system can remain in service throughout the outage and during plant startup until such time sufficient heat load exists to place the Reactor Building Chillers in service.

9.2.12.3.2.2 Component Description

Design data for major components of the Reactor Building Chilled Water System are listed in Table 9.2-17.

9.2.12.3.2.3 System Operation

The Reactor Building Chilled Water System operates continuously. Chilled water is circulated through the supply loop to the air cooling coils. The return chilled water is cooled by the chiller and recirculated.

One chilled water loop circulating pump and one chiller, with its associated evaporator water circulating pump and condenser water circulating pump (a "chiller loop"), normally operate. The other chilled water loop circulating pump and the other chiller loop are normally placed in automatic standby. Either chiller loop may be operated with either chilled water loop circulating pump.

The system is manually started from local panels by starting a selected chilled water loop circulating pump, then an evaporator water circulating pump, which also starts the corresponding condenser water circulating pump, and then the corresponding chiller.

The standby chilled water loop circulating pump will automatically start if the operating pump fails.

The standby chiller loop will automatically start if the operating chiller loop cannot meet demand. If the chilled water return temperature exceeds its setpoint, or if the operating chiller or a circulating pump fails, the standby chiller loop components automatically start, to pick up the load.

Two temperature sensors located downstream of the chillers in the chilled water main supply header modulate the compressor inlet guide vanes of their respective chillers to maintain a constant chilled water supply temperature in the loop.

A temperature controller maintains constant chiller condenser cooling water outlet temperature by modulating temperature control valves on the cooling water return and recirculaton lines.

Three way valves are used for regulating the chilled water flow rate through the cooling coils except those in the drywell unit coolers and recirculation pump motor coolers, which are balanced for constant flow.

The Zone I, Zone II, and Zone III cooling coils are drained and isolated during the winter months to prevent the coils from freezing. During the fall and spring seasons when the cooling coils are still functional, the coils are protected from freezing by low temperature switches mounted on the face of each coil. If the air temperature upstream of the cooling coils drops below the setpoint of the low temperature switches, maximum chilled water flow is routed through the cooling coils.

The Zone III cooling coils are also protected from freezing by energizing the Zone III heaters when outside air temperatures drop below 40°F. This is accomplished by providing the outside air temperature as a second control signal for Zone III heater operation.

There are two sets of unit coolers with seven unit coolers in each set for the drywell. Each set is on a separate piping loop. Two separate piping connections supply chilled water to recirculation pump motor coolers A and B.

An alternate supply of cooling water to the drywell coolers is available from the Reactor Building Closed Cooling Water System. It will be connected automatically under the following conditions: low flow in chilled water loop, high temperature in chilled water loop, or loss of power to chilled water circulating pumps. The cooling can be returned to normal after one of the chillers is restored and the chilled water flow and temperature return to normal.

During a DBA, there will be no chilled water or reactor building closed cooling water supply to the drywell, because the containment isolation valves will be closed.

9.2.12.3.3 Safety Evaluation

The operation of the Reactor Building Chilled Water System has no safety related function. Containment penetration and containment isolation portions of the system are safety related as described in Subsection 6.2.4.

The chilled water piping inside the drywell has been examined to ensure that in the event of a SSE it will have no adverse effects on adjacent safety related equipment.

9.2.12.3.4 Test and Inspections

The system was preoperationally tested in accordance with the requirements of Chapter 14. Provision is made for periodic inspection of major components to ensure the capability and integrity of the system. Local display devices are provided to indicate pressures and temperatures for tests and inspections.

9.2.12.3.5 Instrument Applications

Operation of the water chillers and chilled water pumps will be initiated manually from local control panels. Automatic standby operation of chillers and pumps is provided.
Indications are displayed at the local control panel to show operation status of chillers and pumps. Local indicators display pressures and temperatures required to monitor operation of the chillers and pumps.

Chilled water flow into and out of the containment will be isolated by valves which close on an isolation signal, or on power failure at the valve. For a complete discussion of containment isolation, refer to Section 6.2.4.

The following abnormal conditions are alarmed at the local control panel and retransmitted to the control room as a trouble alarm:

a) Failure of any pump

b) Failure of any chiller

c) High and low water level at the expansion tank

d) Drywell cooling coils outlet water high temperature

9.2.12.4 Radwaste Building Chilled Water System

9.2.12.4.1 Design Bases

The Radwaste Building Chilled Water System has no safety related function.

The Radwaste Building Chilled Water System is designed to supply chilled water at 48ºF to maintain design ambient air temperatures in various areas of the Radwaste Building. Water at 48ºF is supplied first to four coils in the Off Gas System Area Unit Coolers, and thence, in series, to six cooling coils in the Air Supply Unit. Water to the six Air Supply Unit Cooling Coils will be at 56.7ºF or less, with design heat load on the Off Gas System Area Cooling Coils.

The system is designed to permit periodic inspection, testing, and maintenance of principal components with a minimum loss of normal operation.

Codes and standards applicable for the system are discussed in Table 3.2-1.

9.2.12.4.2 System Description

9.2.12.4.2.1 General Description

The system is common to both Units 1 and 2. It consists of two centrifugal water chillers, two evaporator chilled water circulating pumps, two condenser water pumps, two chilled water loop circulating pumps, an air separator, an expansion tank, a chemical addition tank, air cooling coils, interconnecting piping, and controls. Each chiller and pump is sized for 100 percent of nominal system capacity. The system is shown schematically on Dwgs. M-189, Sh. 1, M-189, Sh. 2, M-189, Sh. 3, and M-189, Sh. 4.

Heat gained by the circulating chilled water is removed in the chiller evaporator refrigerant which in turn is cooled by the condenser cooling water.

Cooling water to the chiller condenser is provided from the normal Service Water System.

The makeup water supply to the Radwaste Building Chilled Water System is through the manual valve provided in the makeup connection from the demineralized water system.

The chemical addition subsystem provided to minimize piping corrosion and scale buildup is manually controlled.

An air separator and an expansion tank are provided to accommodate expansion and contraction in the system due to temperature change.

The components of the system are located in the radwaste building.

9.2.12.4.2.2 Component Description

Design data for major components of the Radwaste Building Chilled Water System are listed in Table 9.2-18.

9.2.12.4.2.3 System Operation

The Radwaste Building Chilled Water System is started manually when needed. Chilled water is circulated through the supply loop to the air cooling coils. The return chilled water is cooled by the chiller and recirculated.

One chilled water circulating pump and one chiller, with its associated evaporator water circulating pump and condenser water circulating pump (a "chiller loop"), are normally operated. The other chilled water loop circulating pump and the other chiller loop are normally placed in automatic standby. Either chiller loop may be operated with either chilled water circulating pump.

The system is manually started from local panels by starting a selected chilled water loop circulating pump, then an evaporator water circulating pump, which also starts the corresponding condenser water circulating pump, and then the corresponding chiller.

The standby chilled water loop circulating pump will automatically start if the operating pump fails.

The standby chiller loop will automatically start if the operating chiller loop cannot meet demand. If the chilled water return temperature exceeds its setpoint, or if the operating chiller or a circulating pump fails, the standby chiller loop components automatically start, to pick up the load.

An available feature permits the system to be started automatically when the outside air temperature reaches 52ºF, if desired, by preselecting a chilled water loop circulating pump and a chiller loop. The selected chilled water loop circulating pump will then automatically start on increasing outside air temperature; and the selected evaporator water circulating pump, condenser water circulating pump, and chiller will automatically start in sequence when chilled water loop flow reaches a flow switch setpoint.

Two temperature sensors located downstream of the chillers in the chilled water supply main modulate the compressor inlet guide vanes of their respective chillers to maintain a constant chilled water supply temperature in the loop.

A temperature controller maintains constant chiller condenser cooling water outlet temperature by modulating a three-way valve between the cooling water supply and return line.

Three-way valves are also provided for regulating the chilled water flow rate through the air supply unit and off-gas area unit cooling coils. When the temperature of air upstream of any of the air supply unit cooling coils drops below the set value of the temperature switches, this is annunciated at the local control panel as indication of failure of the upstream heating coil. Further drop of air temperature will be detected by another set of temperature switches, which, together with actuation of a low chilled water flow switch, will initiate the isolation and draining of water in the cooling coils to prevent freezing. . Vacuum breakers provide automatic venting for this drain function. Manual isolation, vent, and drain valves, and a demineralized water connection, permit manual isolation, drain, and fill of the Radwaste Building Supply Unit Cooling Coils; or refilll of the coils after an automatic drain for freeze protection. Manual switches and valves are provided to permit coil drain system testing, if required.

High and low levels of the expansion tank are annunciated locally and as a trouble alarm to the control room. The tank is filled, drained, and pressurized through manual valves.

9.2.12.4.3 Safety Evaluation

Because the Radwaste Building Chilled Water System has no safety design basis, no safety evaluation is provided. However, the system has features that ensure its reliable operation during plant normal operation. These features include redundant equipment such as chillers and pumps. Additional features include fail-safe positions on the system controls and equipment safety controls.

9.2.12.4.4 Tests and Inspections

The system was preoperationally tested in accordance with the requirements of Chapter 14.

Provision is made for periodic inspection of major components to ensure the capability and integrity of the system. Local display devices are provided to indicate pressures and temperatures for tests and inspections.

9.2.12.4.5 Instrument Applications

Operation of the chilled water system will be initiated manually from local control panels. Automatic standby operation of chillers and pumps is provided.

Indications displayed on the local control panel give the operating status of chillers and pumps. Local indicators display pressures and temperatures required to monitor operation of the chillers and pumps.

The following abnormal conditions are alarmed at the local control panel and retransmitted to the control room as a trouble alarm:

a) Failure of any pump

b) Failure of any chiller

c) High and low water level in the expansion tank

d) Low air temperature at the upstream side of the air supply unit cooling coils

9.2.13 References

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TABLE 9.2-1

LIST OF COOLERS SUPPLIED COOLING WATER BY THE SERVICE WATER SYSTEM

1.	Generator Stator Coolers
2.	Generator Hydrogen Coolers
3.	Alterrex Air Coolers
4.	Iso-Phase Bus Coolers
5.	Gaseous Radwaste Recombiner CCW Heat Exchangers
6.	Turbine Building CCW Heat Exchangers
7.	Turbine Lube Oil Coolers
8.	Reactor Feed Pump Turbine Lube Oil Coolers
9.	Reactor Recirculation Pump M-G Set Fluid Coolers
10.	Reactor Building CCW Heat Exchangers
11.	Fuel Pool Heat Exchangers
12.	Pipe Tunnel Coolers
13.	Turbine Building Chillers
14.	Reactor Building Chillers
15.	Control Structure Chillers
16.	Radwaste Building Chillers
17.	Radwaste Evaporator Condensers[1]
18.	Containment ILRT Aftercooler and Air Dryer
19.	Degasifier Seal Water Cooler

[1] Permanently valved out of service

Table Rev 55

TABLE 9.2-3

DEFINITION OF ESW FLOWS FOR UNITS 1 & 2

Component	Number of Users Per Loop		Minimum Required ESW Flow per User (GPM)	Minimum Required ESW Flow For DBA and 1 Loop Failed	Typical Minimum ESW Loop Flow Non-Accident with 1 Loop Operating and Service Water Available	Typical Minimum[5] ESW Safe Shutdown Flow 2 Loops Operating and Both Units Service Water Not Available	
	U1	U2				A(B)	B(A)
1) Standby[4] Diesel Generator Heat Exchangers	4 common total		1029 (A & C) 922 (B & D) 1282 (E)[3]	3902 (A,B,C,D) 4155 (B,C,D,E) 4262 (A,B,C,E)	3902 (A,B,C,D) 4155 (B,C,D,E) 4262 (A,B,C,E)	3902[2] 4155[2] 4262[2]	- - -
2) RHR Pump Room Unit Coolers	2	2	90	360	360	360	360
3) RHR Pump Motor Bearing Oil Cooler (7)	3	3	7.5	45	45	30	30
4) Core Spray Pump Room Unit Coolers	2	2	15	60	60	60	60
5) HPCI Pump Room Unit Coolers	1	1	10	20	20	20	20
6) RCIC Pump Room Unit Coolers	1	1	10	20	20	20	20
7) Control Structure Chiller	1 common per loop		737	737	-	737	-
8) Emergency Switch-gear Cooling Condensing Unit	-	1	110	110	-	110	-
9) RBCCW Heat Exchanger[1]	1	1	900	-	-	-	See Note 1
10) TBCCW Heat Exchanger [1]	1	1	100	-	-	-	See Note 1
11) Makeup to Fuel Pools[6]	1	1	35	70	-	70	-
TOTAL Loop Flow (GPM)			-	5254[2] 5507[2] 5614[2]	4407[2] 4660[2] 4767[2]	5239[2] 5492[2] 5599[2]	490

TABLE 9.2-3

DEFINITION OF ESW FLOWS FOR UNITS 1 & 2

NOTES:

1) One loop only. Not required to meet the system design function. This equipment is aligned when permitted by operating procedures to assist in shutdown operations. Per procedure, RBCCW is not aligned to ESW if a spray pond bypass valve fails.

2) Values shown are dependent on the combination of Diesel Generators operating, since flow rates for the 'A' & 'C' Diesel Generators are different from flows for the 'B' & 'D' Diesel Generators and required flows for the 'E' Diesel Generator are different from all the others.

3) The 'E' Diesel Generator flow rate shown on this table is based on the continuous duty rating of the Diesel Generator (5000 kw).

4) Both loops of ESW are aligned to the Diesel Generators. It is preferred that one pump per loop be run during normal operations. However, in the event of a DBA and a single failure in ESW, one loop will be available to supply the design flow to the Diesel Generator.

5) This column illustrates the ESW systems ability to supply DBA flows in addition to supplying TBCCW and RBCCW with both loops operating. The actual flow rates in each loop will vary slightly because of the crosstie at the diesels (that is, the 'B' loop will pass some flow to the Diesel Generators).

6) The make-up rate shown here is conservatively based on a non-mechanistic boiling spent fuel pool (See Subsection 9.1.3.3). The flow rate for make-up of evaporative losses during RHR fuel pool cooling operation would be significantly less.

7) Both loops of ESW are aligned to RHR pump motor bearing oil coolers 1E217C, 1E217D, 2E217C and 2E217D. With one loop operating, ESW will provide cooling to three Unit 1 and three Unit 2 RHR pump motor bearing oil coolers.

Table 9.2-4

ESW COOLING DUTY FOLLOWING DBA FOR MINIMUM HEAT TRANSFER CASE

(LOSS OF ALL AUXILIARY POWER FOLLOWED BY A SINGLE UNIT LOCA)

Security-Related Information

Table Withheld Under 10 CFR 2.390

Table Rev. 54

TABLE 9.2-5

ESW COOLING DUTY FOLLOWING DBA FOR MAXIMUM WATER LOSS CASE (LOSS OF ALL AUXILIARY POWER FOLLOWED BY A SINGLE UNIT LOCA)

Time	Operating Safeguards	LOCA Unit	S/D Unit	Cooling Duties On ESW	Number in Use LOCA Unit	Number in Use S/D Unit	Total ESW Cooling Duty* ($x10^6$ BTU/Hr)
0 – 10 Mins.	1) RHR Pumps	4-LPCI	0	1) Diesel-generator Hx	4-Common		42.49
	2) RHR Hx's	0	0				
				2) Control Structure Chiller	1-Common		3.67
	3) CS Pumps	4	0				
				3) Emergency Switchgear Cooling Condensing Unit	1-Unit 2 Only		0.63
	4) RCIC Pumps	1	1				
	5) HPCI Pumps	1	0				
	6) RHR SW Pumps	0	0	4) RBCCW Hx	1	1	15.4**
				5) TBCCW Hx	1	1	0.48**
	7) ESW Pumps	All 4 Running	All 4 Running	6) RHR Room Cooler	4	--	2.01
				7) RHR Motor Oil Cooler	4	--	0.22
	8) Diesels	4 Running	4 Running				
				8) C.S. Room Cooler	4	--	0.79
				9) HPCI Room Cooler	1	-	.140
				10) RCIC Room Cooler	1		0.20
						TOTAL	66.03
10 Mins to 3Hrs.	1) RHR Pumps	2-Pool Cool	2-Pool Cool	1) Diesel-generator Hx	4-Common		42.49
	2) RHR Hx's	2	2				
				2) Control Structure Chiller	1-Common		3.67
	3) CS Pumps	4	0				
				3) Emergency Switchgear Cooling Condensing Unit	1-Unit 2 Only		0.63
	4) RCIC Pumps	1	1				
	5) HPCI Pumps	1	0				
	6) RHR SW Pumps	2	2	4) RBCCW Hx	1	1	15.4**
				5) TBCCW Hx	1	1	0.48**
	7) ESW Pumps	All 4 Running	All 4 Running	6) RHR Room Cooler	2	2	2.01
	8) Diesels	4 Running	4 Running	7) RHR Motor Oil Cooler	2	2	0.22
				8) C.S. Room Cooler	4	--	0.79
				9) RCIC Room Cooler	1	1	0.20
				10) HPCI Room Cooler	1	--	0.14
						TOTAL	66.08

Table Rev. 54

TABLE 9.2-5

ESW COOLING DUTY FOLLOWING DBA FOR MAXIMUM WATER LOSS CASE (LOSS OF ALL AUXILIARY POWER FOLLOWED BY A SINGLE UNIT LOCA)

Time	Operating Safeguards	LOCA Unit	S/D Unit	Cooling Duties On ESW	Number in Use LOCA Unit	Number in Use S/D Unit	Total ESW Cooling Duty* ($x10^6$ BTU/Hr)
Approx. 3 hrs. to 30 days	1) RHR Pumps	2-Pool Cool	Shutdown Cool 1 - FPC	1) Diesel-generator Hx	4-Common		42.49
	2) RHR Hx's	2	2	2) Control Structure Chiller	1-Common		3.67
	3) CS Pumps	4	0	3) Emergency Switchgear Cooling Condensing Unit	1-Unit 2 Only		0.63
	4) RCIC Pumps	0	0	4) RBCCW Hx	1	1	15.4**
	5) HPCI Pumps	0	0	5) TBCCW Hx	1	1	0.48**
	6) RHR SW Pumps	2	2	6) RHR Room Cooler	2	2	2.01
				7) RHR Motor Oil Cooler	2	2	0.22
	7) ESW Pumps	All 4 Running	All 4 Running				
	8) Diesels	4 Running	4 Running	8) C.S. Room Cooler	4	--	0.79
						TOTAL	65.69

NOTE:

* Value with the "E" Diesel Generator Unit in service as a replacement for one of the diesel generators A,B, C or D. Heat loads shown for Diesel Generator "E" are based on the continuous duty rating of the diesel generator (5000 KW)

** This equipment is not required to meet the system design function.

TABLE 9.2-6

ULTIMATE HEAT SINK COMPONENTS

	Details
Emergency Service Water Pumps	
Quantity	4 pumps
Type	Vertical, wet-pit, centrifugal
Rated capacity/total head (each)	6000 gpm/230 ft
Brake horsepower	450
Speed, rpm	1780
RHR Service Water Pumps	
Quantity	4 pumps, 2 per unit (1 each is on standby)
Type	Vertical, wet-pit, centrifugal
Rated capacity/total head (each)	9000 gpm/222 ft
Brake horsepower	600
Speed, rpm	1180

Note: Performance data is approximate. Refer to design documents for exact values.

TABLE 9.2-7

SPRAY POND DESIGN DATA

	Details
Spray Nozzles	
Number	484/loop, two loops
Type	Hollow-cone spray pattern
Capacity each, gpm	53
Spray Pond	
Size, surface area	8 acres
Capacity, gal	25 x 10^6 gals
Lining	Concrete

TABLE 9.2-8
SUSQUEHANNA POND WATER ALLOWANCES

LOSS DESCRIPTION	WATER ALLOWANCE ($x10^6$ GAL.)
a) Evaporation due to heat dissipation duty for maximum water loss case. Includes maximum solar evaporation losses.	14.96
b) Drift from wind for maximum water loss case.	3.28
c) System charging volume.	Negligible
d) Losses resulting from wave action.(1)	0
e) Fuel pool makeup and boundary valve leakage(5)	3.0
TOTAL POND VOLUME REQUIRED	21.24
TOTAL POND VOLUME PROVIDED(4)	22.2

(1) Based on design provisions for protection from this loss.

(2) Deleted

(3) Deleted

(4) Based on the Technical Specification low level limit. Volume accounts for 6 in. of pond depth lost due to sedimentation, which is conservative allowance between cleaning periods.

(5) A conservative value of 70 gpm over the 30-day transient is used to account for potential boundary valve leakage in the ESW system. No fuel pool makeup is required since pool cooling per RHR fuel pool cooling mode is assumed for the maximum water loss case.

TABLE 9.2-9

MINIMUM HEAT TRANSFER METEOROLOGY - SITE DATA
FIRST OF THE TWO WORST CONSECUTIVE DAYS
AUGUST 2, 1975

TIME (HR)	WET BULB TEMP (°F)	DRY BULB TEMP(°F)	DEW POINT TEMP (°F)	WIND SPEED (MPH)	CLOUD COVER* (TENTHS)
0	70	71	70	2.2	0
1	70	71	70	2.2	--
2	70	70	70	1.8	--
3	69	69	69	2.4	--
4	68	69	69	1.3	0
5	68	68	68	1.5	--
6	68	68	68	1.5	--
7	68	68	68	1.0	3
8	69	70	69	1.5	--
9	70	71	70	1.7	--
10	71	73	70	2.7	0
11	75	80	73	2.0	--
12	77	86	74	2.1	--
13	78	88	75	2.5	2
14	78	89	74	3.2	--
15	77	89	73	2.2	--
16	77	89	73	1.6	2
17	78	89	74	1.1	--
18	77	88	73	2.0	--
19	77	85	74	1.7	1
20	78	80	77	2.3	--
21	77	77	77	2.2	--
22	75	75	75	2.3	0
23	74	74	74	1.7	--
24	73	73	73	1.3	0

* Avoca Airport data used for cloud cover.

TABLE 9.2-9 (Continued)

MINIMUM HEAT TRANSFER METEOROLOGY - SITE DATA
WORST DAY
AUGUST 16, 1978

TIME (HR)	WET BULB TEMP (°F)	DRY BULB TEMP(°F)	DEW POINT TEMP (°F)	WIND SPEED (MPH)	CLOUD COVER* (TENTHS)
25	72	76	70	1.2	0
26	71	74	70	1.1	0
27	71	73	70	1.2	0
28	70	72	69	1.0	3
29	69	71	68	1.3	2
30	69	71	68	1.2	2
31	70	73	69	1.1	3
32	72	75	71	1.3	2
33	74	78	72	3.1	3
34	74	80	71	4.0	3
35	74	82	71	3.8	3
36	75	84	72	4.5	3
37	75	84	71	5.7	3
38	75	86	70	6.4	3
39	75	86	70	4.8	2
40	75	85	71	4.4	3
41	74	85	70	4.7	1
42	75	84	71	3.3	2
43	73	82	70	3.5	3
44	73	80	70	2.8	7
45	73	80	71	3.6	4
46	74	79	72	4.2	2
47	73	78	71	2.3	0
48	72	78	70	2.3	0

* Avoca Airport data used for cloud cover.

TABLE 9.2-9 (Continued)

MINIMUM HEAT TRANSFER METEOROLOGY - SITE DATA
SECOND OF THE TWO WORST CONSECUTIVE DAYS
AUGUST 3, 1975

TIME (HR)	WET BULB TEMP (°F)	DRY BULB TEMP(°F)	DEW POINT TEMP (°F)	WIND SPEED (MPH)	CLOUD COVER* (TENTHS)
49	72	72	72	1.5	--
50	70	70	70	2.7	--
51	69	70	69	2.2	0
52	68	69	68	1.7	--
53	68	69	68	1.7	--
54	68	68	68	2.6	2
55	68	68	68	2.1	--
56	69	70	68	1.6	--
57	71	72	71	1.7	0
58	74	77	73	1.9	--
59	76	83	74	1.9	--
60	78	86	75	2.3	1
61	76	88	72	3.2	--
62	76	90	71	4.2	--
63	74	91	67	3.1	0
64	73	89	66	2.8	--
65	75	87	71	2.8	--
66	76	86	72	2.0	4
67	77	83	75	1.7	--
68	77	80	76	4.3	--
69	73	79	71	3.6	0
70	70	76	67	2.5	--
71	70	75	68	3.7	--
72	70	74	68	3.2	0

- Avoca Airport data used for cloud cover.

TABLE 9.2-9 (Continued)

MINIMUM HEAT TRANSFER METEOROLOGY - SITE DATA
WORST 30 CONSECUTIVE DAYS
30-DAY AVERAGES BY TIME OF DAY
JULY 8, 1979 THROUGH AUGUST 6, 1979

TIME (HR)	WET BULB TEMP (°F)	DRY BULB TEMP(°F)	DEW POINT TEMP (°F)	WIND SPEED (MPH)	CLOUD COVER* (TENTHS)
73	65	67	64	1.8	2
74	64	66	63	1.9	2
75	64	66	63	1.9	1
76	64	65	63	2.0	1
77	63	65	62	1.8	2
78	63	65	62	1.8	2
79	64	66	63	1.9	2
80	66	68	65	2.1	2
81	68	71	66	2.7	2
82	69	74	66	2.9	3
83	70	77	66	3.5	3
84	70	78	66	3.7	2
85	70	80	65	4.1	4
86	70	80	65	3.9	4
87	70	80	65	4.1	4
88	70	80	65	3.9	4
89	70	79	65	3.7	4
90	69	78	65	3.1	4
91	69	77	65	2.4	3
92	69	74	66	2.1	3
93	68	72	66	2.0	3
94	67	70	65	1.8	2
95	66	69	65	1.9	2
96	65	68	64	1.8	1

* Avoca Airport data used for cloud cover.

** Data of this 24-hour period is repeated 27 times to constitute the balance of the 30-day meteorology.

TABLE 9.2-10

MAXIMUM WATER LOSS METEOROLOGY
AVOCA AIRPORT DATA

HOURLY AVERAGE DATA FOR WORST 30 DAYS
MARCH 6, 1951 THROUGH APRIL 4, 1951

TIME (HR)*	DRY BULB TEMP (°F)	WET BULB TEMP (°F)	WIND SPEED (mph)	DEW POINT TEMP (°F)	RELATIVE HUMIDITY (%)	CLOUD COVER (Tenths)
0	35.033	32.433	11.740	27.733	75.633	1
1	34.567	32.233	10.512	27.800	77.000	1
2	34.000	31.700	10.282	27.400	77.500	0
3	33.767	31.533	10.858	27.167	77.533	1
4	33.300	31.133	10.090	26.867	78.067	1
5	33.167	30.967	11.548	26.667	77.633	1
6	32.833	30.700	10.781	25.933	75.467	1
7	33.667	31.133	11.165	26.167	74.867	2
8	35.100	32.167	11.088	26.967	73.333	2
9	36.733	33.300	13.045	27.233	69.867	2
10	38.767	34.800	13.965	27.900	66.267	2
11	40.633	35.900	14.464	28.233	62.767	2
12	42.233	36.900	16.191	28.600	60.833	3
13	42.867	37.367	17.073	28.967	60.033	2
14	43.367	37.800	17.303	29.133	59.233	3
15	43.433	37.767	17.342	29.133	59.200	3
16	42.900	37.633	15.730	29.633	61.500	2
17	41.933	36.933	14.119	29.333	62.900	2
18	40.367	36.267	12.508	29.633	67.233	2
19	38.867	35.167	11.970	28.967	69.100	2
20	37.700	34.467	12.968	28.967	72.067	1
21	36.567	33.767	12.201	28.933	74.900	2
22	36.200	33.533	11.932	28.967	76.000	1
23	35.833	33.033	12.277	28.200	74.733	1

* Data of this 24-hour period is repeated 30 times to constitute the balance of the 30-day meteorology.

TABLE 9.2-12
SUMMARY OF PEAK TEMPERATURE VALUES AND FINAL POND WATER INVENTORY

Parameter	Maximum Water Loss	Minimum Heat Transfer
Peak pond temperature	N/A	97
Calculated water inventory @ 30 days	0.97×10^6 gal	3.99×10^6 gal

TABLE 9.2-13

CONDENSATE & REFUELING WATER STORAGE FLOW PATHS

VALVE NUMBER

MODE	008001	008003	008004	008011	008009	008016	008038	008037	208034	008035	008039	008034	108028	008032	008081	008033	008078	008077	008079	008084
From Refueling Storage Tank																				
1	0	0	0	0	0	0	0	0					0							
2	0	0	0	0	0	0	0	0	0											
3	0	0	0	0	0	0	0			0		0								
4	0	0	0	0	0	0					0						0	0		0
5	0	0	0	0	0	0					0									
6	0	0	0	0	0	0					0						0			
7	0											0				0				
8	0						0			0	0					0	0	0		*0
9	0											0				0				
From Reactor Well Unit 1																				
10		0	0	0	0	0		0		0	0		0			0				
11		0	0	0	0	0		0		0	0		0			0	0			
12							0	0			0		0							
13							0	0			0		0				0			
14	0							0		0			0			0				
15								0		0		0	0							
16							0	0			0		0				0	0		0
From Reactor Well Unit 2																				
17																				
18																				
19																				
20	Same as 10 -16 except Valve 108028 closed and Valve 208034 open																			
21																				
22																				
23																				

MODE	008083	008029	008036	008040	008050	008048	008057	008093	008074	008028	008F009A	008F009B	008002	008094	008102	008100	008095	008103	008111	008113
From Refueling Storage Tank																				
1													0							
2													0							
3		0											0						0	
4													0							
5														0						
6															0					
7		*0								*0			0						0	
8	*0												0							
9			0	0	0								0						0	
From Reactor Well Unit 1																				
10														0						
11															0					
12														0						
13															0					
14													0							
15		0																	0	
16																				
From Reactor Well Unit 2																				
17																				
18																				
19																				
20																				
21																				
22																				
23																				

0 - Valve
* - Open either valve depending on level in tank

TABLE 9.2-13

CONDENSATE & REFUELING WATER STORAGE FLOW PATHS

VALVE NUMBER

MODE	008001	008003	008004	008011	008009	008016	008038	008037	208034	008035	008039	008034	108028	008032	008081	008033	008078	008077	008079	008084	008083	008029	008036	008040	008050	008048	008057	008093	008074	008028	008F009A	008F009B	008002	008094	008102	008100	008095	008103	008111	008113
From Condensate Storage Tank - Unit 1																																								
24																					0	0	0	0	0	0		0											
25																					0	0	0	0	0	0	0												
26																0					0	0	0	0	0	0	0						0	0					
27																0	0		0		0	0	0	0	0	0	0						0						
28	0						0			0	0					0						0	0	0	0	0	0	0					0	0						
29																			0	*0	*0	*0	0							*0						0				
30	0											0				0						0											0						0	
31																															0									
From Condensate Storage Tank - Unit 2																																								
32																			0	0	*0			0	0	0	0		0							0				
33																			0	0	*0			0	0	0	0	0								0				
34																0			0	0	*0			0	0	0	0	0						0	0	0				
35							0			0	0	0							0	0	*0	0		0	0	0	0	0						0		0			0	
36	0						0			0	0					0			0	0	*0			0	0	0	0	0					0	0		0				
37																			0	0	*0	0	0							*0						0				
38	0											0				0			0	0	*0		0										0			0			0	
39																																0								
From Condensate Filter Demineralizer - Unit 1																																								
40	0											0				0						*0								*0			0				0		0	0
41	0						0			0	0					0	0	0		*0	*0												0				0			0
42	Direct-By Opening Valves at Demineralizer																																				0			0
43	0											0				0							0	0	0								0				0		0	0
44	0	0	0	0																													0				0			0
From Condensate Filter Demineralizer - Unit 2																																								
45																																								
46																																								
47	Same as 40 - 44 but in addition open valve 008103 and close valve 008095																																							
48																																								
49																																								

0 - Valve
* - Open either valve depending on level in tank

TABLE 9.2-13

CONDENSATE & REFUELING WATER STORAGE FLOW PATHS

VALVE NUMBER (columns 008001 – 008081)

MODE	008001	008003	008004	008011	008009	008016	008038	008037	208034	008035	008039	008034	108028	008032	008081	008033	008078	008077	008079	008084
To & From Hotwell Makeup & Reject Station - Unit 1																				
50														0						
51														0					0	*0
52	0											0		0		0				
To & From Hotwell Makeup & Reject Station - Unit 2																				
53															0				0	*0
54															0					
55	0											0			0	0			0	*0

VALVE NUMBER (columns 008083 – 008113)

MODE	008083	008029	008036	008040	008050	008048	008057	008093	008074	008028	008F009A	008F009B	008002	008094	008102	008100	008095	008103	008111	008113
To & From Hotwell Makeup & Reject Station - Unit 1																				
50																				
51	*0	*0	0							*0						0				
52		*0								*0			0						0	
To & From Hotwell Makeup & Reject Station - Unit 2																				
53	*0	*0	0							*0						0				
54																				
55	*0		0										0			0			0	

0 - Valve
* - Open either valve depending on level in tank

NOTES:

FROM REFUELING STORAGE TANK

Mode

1. To Reactor Well - Unit 1
2. To Reactor Well - Unit 2
3. To Cond. Storage Tank - Unit 1 Via Refueling Water Pumps
4. To Cond. Storage Tank - Unit 2 Via Refueling Water Pumps
5. To Cond. Filter Demin. - Unit 1
6. To Cond. Filter Demin. - Unit 2
7. To Cond. Storage Tank - Unit 1
8. To Cond. Storage Tank - Unit 2
9. To Cond. Transfer Pumps

TABLE 9.2-13

CONDENSATE & REFUELING WATER STORAGE FLOW PATHS

FROM REACTOR WELL - UNIT 1

Mode

10. To Cond. Filter Demin. - Unit 1 Via Refueling Water Pumps
11. To Cond. Filter Demin. - Unit 2 Via Refueling Water Pumps
12. To Cond. Filter Demin. - Unit 1
13. To Cond. Filter Demin. - Unit 2
14. To Refueling Storage Tank
15. To Cond. Storage Tank - Unit 1
16. To Cond. Storage Tank - Unit 2

FROM REACTOR WELL - UNIT 2

Mode

17. To Cond. Filter Demin. - Unit 1 Via Refueling Water Pumps
18. To Cond. Filter Demin. - Unit 2 Via Refueling Water Pumps
19. To Cond. Filter Demin. - Unit 1
20. To Cond. Filter Demin. - Unit 2
21. To Refueling Storage Tank
22. To Cond. Storage Tank - Unit 1
23. To Cond. Storage Tank - Unit 2

FROM CONDENSATE STORAGE TANK - UNIT 1

Mode

24. To Radwaste Equipment
25. To Cond. Filter Demin. - Unit 1 Via Cond. Transfer Pumps
26. To Cond. Filter Demin. - Unit 2 Via Cond. Transfer Pumps
27. To Cond. Storage Tank - Unit 2 Via Cond. Transfer Pumps
28. To Refueling Storage Tank Via Cond. Transfer Pumps
29. To Cond. Storage Tank - Unit 2
30. To Refueling Storage Tank
31. To RCIC & HPCI - Unit 1

FROM CONDENSATE STORAGE TANK - UNIT 2

Mode

32. To Radwaste Equipment
33. To Cond Filter Demin. Unit 1 Via Cond. Transfer Pumps
34. To Cond. Filter Demin. - Unit 2 Via Cond. Transfer Pumps
35. To Cond. Storage Tank - Unit 1 Via Cond. Transfer Pumps
36. To Refueling Storage Tank Via Cond. Transfer Pumps
37. To Cond. Storage Tank - Unit 1
38. To Refueling Storage Tank
39. To RCIC & HPCI - Unit 2

FROM CONDENSATE FILTER DEMINERALIZER - UNIT 1

Mode

40. To Cond. Storage Tank - Unit 1 Via Refueling Water Storage Tank
41. To Cond. Storage Tank - Unit 2 Via Refueling Water Storage Tank
42. To Refueling Storage Tank
43. To Cond. Transfer Pumps Via Refueling Water Storage Tank
44. To Refueling Water Pumps Via Refueling Water Storage Tank

FROM CONDENSATE FILTER DEMINERALIZER - UNIT 2

Mode

45. To Cond. Storage Tank - Unit 1 Via Refueling Water Storage Tank
46. To Cond. Storage Tank - Unit 2 Via Refueling Water Storage Tank
47. To Refueling Storage Tank
48. To Cond. Transfer Pumps Via Refueling Water Storage Tank
49. To Refueling Water Pumps Via Refueling Water Storage Tank

TO & FROM HOTWELL MAKEUP & REJECT STATION - UNIT 1

Mode

50. Cond. Storage Tank - Unit 1 - Direct
51. Cond. Storage Tank - Unit 2 Via Unit 1 Condensate Storage Tank
52. Refueling Storage Tank Via Unit 1 Condensate Storage Tank

TO & FROM HOTWELL MAKEUP & REJECT STATION - UNIT 2

Mode

53. Cond. Storage Tank - Unit 1 Via Unit 2 Condensate Storage Tank
54. Cond. Storage Tank - Unit 2 - Direct
55. Refueling Storage Tank Via Unit 2 Condensate Storage Tank

TABLE 9.2-14

CONTROL STRUCTURE CHILLED WATER SYSTEM DESIGN DATA

Centrifugal Water Chillers	
Quantity	2
Type	Centrifugal
Capacity, tons	230
Motor, hp	351
Entering water temperature	54°F
Leaving water temperature	44°F
Chilled Water Pumps	
Quantity	2
Type	Horizontal centrifugal
Flow rate, gpm	565
Head, ft	78
Motor, hp	30
Condenser Water Pumps (Normal Service Water)	
Quantity	2
Type	Horizontal centrifugal
Flow rate, gpm	740
Head, ft	65
Motor, hp	20
Closed Expansion Tank	
Quantity	2
Capacity, gal	33
Design pressure, psig	125
Air Separator	
Quantity	2
Design pressure, psig	125
Flow rate, gpm	565
Chemical Addition Tank	
Quantity	2
Design pressure, psig	100
Capacity, gal	15
Condenser Water Pumps (Emergency Service Water)	
Quantity	2
Type	Horizontal centrifugal
Flow rate, gpm	740
Head, ft	54 (Rated)
Motor, hp	20

TABLE 9.2-15

CONTROL STRUCTURE CHILLED WATER SYSTEMS
FAILURE MODE AND EFFECT ANALYSIS

PLANT OPERATING MODE	SYSTEM COMPONENT	COMPONENT FAILURE MODE	EFFECT OF FAILURE ON THE SYSTEM	FAILURE MODE DETECTION	EFFECT OF FAILURE ON PLANT OPERATION
Emergency	Power supply	Total loss of offsite power (LOOP)	None. The two redundant systems are powered from separate diesel generators.	Alarm in the control room	No loss of safety function
Emergency (LOCA or LOCA + LOOP)	Chilled water loop circ pumps (OP-162)	Pump failure	None. The standby chiller train automatically starts.	Alarm in the control room	No loss of safety function
Emergency (LOCA or LOCA + LOOP)	Chiller units (OK-112)	Chiller failure	None. When the chiller fails it trips the chilled water loop circulating pump and the standby chiller train automatically starts.	Alarm in the control room	No loss of safety function
Emergency (LOCA or LOCA + LOOP)	Emergency condenser water circ pumps (OP-171)	Pump failure	None. When the pump fails it trips the chilled water loop circulating pump and the standby chiller train automatically starts.	Alarm in the control room	No loss of safety function
Emergency (LOCA or LOCA + LOOP)	Emergency condenser water loop 3-way valves (TV-08612)	Valve failure	None. Eventually, the chiller will trip and in turn trip the chilled water loop circulating pump and the standby chiller train will automatically start.	Alarm in the control room	No loss of safety function

TABLE 9.2-15 (Continued)

CONTROL STRUCTURE CHILLED WATER SYSTEMS
FAILURE MODE AND EFFECT ANALYSIS

PLANT OPERATING MODE	SYSTEM COMPONENT	COMPONENT FAILURE MODE	EFFECT OF FAILURE ON THE SYSTEM	FAILURE MODE DETECTION	EFFECT OF FAILURE ON PLANT OPERATION
Emergency (LOCA or LOCA + LOOP)	Emergency condenser water loop valves (HV-08613)	Valve failure	None. The valves fail "as is". If the valve fails fully closed it may result in a complete loss of condenser water and cause the chiller to trip. The standby chiller will automatically start. If the valve fails at any intermediate position the chiller will eventually trip through its safety circuit. The standby chiller will also automatically start.	Alarm in the control room	No loss of safety function
Emergency (LOCA or LOCA + LOOP)	Chilled water piping	Rupture or leak in the piping	None. Loss of water in the loop is detected at the expansion tank and is alarmed in the control room. Major loss of water will automatically start the standby chiller.	Alarm in the control room	No loss of safety function

TABLE 9.2-16

TURBINE BUILDING CHILLED WATER SYSTEM DESIGN DATA (PER UNIT)

Centrifugal Water Chillers*	
Quantity	2
Type	Centrifugal
Capacity, tons	800
Motor, hp	1080
Entering water temperature, °F	64
Leaving water temperature, °F	49
Chilled water supply temperature to the cooling coils, °F	52
Evaporator Chilled Water Circulation Pumps	
Quantity	2
Type	Horizontal centrifugal
Flow rate, gpm	1280
Head, ft	50
Motor, hp	25
Condenser Water Pumps	
Quantity	2
Type	Horizontal centrifugal
Flow rate, gpm	2500
Head, ft	70
Motor, hp	60
Closed Expansion Tank	
Quantity	1
Capacity, gal	64
Design pressure, psig	125
Air Separator	
Quantity	1
Design pressure, psig	125
Flow rate, gpm	2300
Chemical Addition Tank	
Quantity	1
Design pressure, psig	100
Capacity, gal	15
Chilled Water Loop Circulation Pumps	
Quantity	2
Type	Horizontal centrifugal
Flow rate, gpm	2300
Head, ft	70
Motor, hp	60

* These temperatures are calculated operating values for maximum design cooling load on the Turbine Building Chilled Water system, for one chiller operating at its design 800-ton load, and with the second chiller removing the remainder of the system design load. Chillers were purchased for nominal 65°F entering and 50°F leaving temperatures to support a nominal 50°F chilled water supply temperature.

TABLE 9.2-17

REACTOR BUILDING CHILLED WATER SYSTEM DESIGN DATA

(PER UNIT)

Centrifugal Water Chillers	
Quantity	2
Type	Centrifugal
Capacity, tons	715
Motor, hp	904
Entering water temperature	68°F
Leaving water temperature	50°F
Chilled water supply temperature to the Cooling Coils	50°F
Evaporator Chilled Water Circulation Pumps	
Quantity	2
Type	Horizontal Centrifugal
Flow Rate, gpm	960
Head, ft.	40
Motor, hp	15
Condenser Water Pumps	
Quantity	2
Type	Horizontal Centrifugal
Flow Rate, GPM	1860
Head, ft.	65
Motor, hp	40
Closed Expansion Tank	
Quantity	1
Capacity, gal.	64
Design pressure, psig	125
Air Separator	
Quantity	1
Design pressure, psig	125
Flow Rate, gpm	1265
Chemical Addition Tank	
Quantity	1
Design Pressure, psig	100
Capacity, gal.	15
Chilled Water Loop Circulation Pumps	
Quantity	2
Type	Horizontal Centrifugal
Flow Rate, gpm	1265
Head, ft.	85
Motor, hp	40

TABLE 9.2-18

RADWASTE BUILDING CHILLED WATER SYSTEM DESIGN DATA

Centrifugal Water Chillers	
Quantity	2
Type	Centrifugal
Capacity, tons	250
Motor, hp	350
Entering water temperature, °F	70
Leaving water temperature, °F	48
Chilled water supply temperature to the Offgas Area Cooling Coils, °F	48
Chilled water supply to Supply Cooling Coils from Offgas Area Cooling Coil outlet and bypass, °F (max.)	56.7
Evaporator Chilled Water Circulation Pumps	
Quantity	2
Type	Horizontal centrifugal
Flow rate, gpm	275
Head, ft	38
Motor, hp	5
Condenser Water Pumps	
Quantity	2
Type	Horizontal centrifugal
Flow rate, gpm	605
Head, ft	44
Motor, hp	10
Closed Expansion Tank	
Quantity	1
Capacity, gal	23
Design pressure, psig	125
Air Separator	
Quantity	1
Design pressure, psig	125
Flow rate, gpm	275
Chemical Addition Tank	
Quantity	1
Design pressure, psig	100
Capacity, gal	15
Chilled Water Loop Circulation Pumps	
Quantity	2
Type	Horizontal centrifugal
Flow rate, gpm	275
Head, ft	90
Motor, hp	10

TABLE 9.2-19

DECAY HEAT GENERATION
ANSI/ANS-5.1-1979, 4031 MWt
FOR ONE CORE

Time, min.	Decay Heat, %	Decay Heat, MBtu/hr.
0	7.22	993.3
10	2.45	337.1
30	1.85	254.5
180	1.04	142.9
250	0.95	130.8
500	0.80	110.1
1000	0.67	92.8
1500	0.61	84.1
2500	0.54	74.8
43200	0.24	33.5

TABLE 9.2-20

EMERGENCY SERVICE WATER SYSTEM HEAT LOADS (BOTH UNITS)
(X 10^6 BTU/HR)

I. Minimum Heat Transfer (MHT) Case*

Time	Loop A	Loop B	Diesels Operating
0 – 10 min.	21.84	37.36	4
10 min. – 3 hrs.	22.19	37.71	4
3 hrs. – 30 days	49.14	0.00	4

II. Maximum Water Loss (MWL) Case*

Time	Loop A	Loop B	Diesel Operating
0 – 10 min.	34.08	32.82	4
10 min. – 3 hrs.	34.43	33.17	4
3 hrs. – 30 days	34.33	32.93	4

* Heat loads include the ESW and RHRSW pump work heat equivalent.

TABLE 9.2-21

RHR AND RHR SERVICE WATER SYSTEM FLOW RATES (GPM)
MINMUM HEAT TRANSFER CASE

TIME	PARAMETER	LOCA	S/D
10-180 min.	Core Spray (2 loops)	12,700	0
	Safety Relief valves & RCICS	0	(1)
	RHRHX (tube side) Flow, Loop A	8,000	8,000
	RHRHX (tube side) Flow, Loop B	8,000	8,000
	RHRHX (shell side) Flow, Loop A	10,000	10,000
	RHRHX (shell side) Flow, Loop B	10,000	10,000
180 min. – 30 days	Core Spray (1 loop)	6,350	0
	RHRHX (tube side) Flow, Loop A	8,000	8,000
	RHRHX (tube side) Flow, Loop B	0	0
	RHRHX (shell side) Flow, Loop A	10,000	10,000
	RHRHX (shell side) Flow, Loop B	0	0

Note: (1) The flow rate is determined by the cooldown rate.

(2) LOCA Unit RHR Flow Rates denote the suppression pool cooling mode of operation.

(3) S/D Unit RHR Flow Rates denote the suppression pool cooling mode of operation for approximately the first three hours of the transient followed by the shutdown cooling mode of operation for the remainder of the thirty-day period.

TABLE 9.2-21a

RHR AND RHR SERVICE WATER SYSTEM FLOW RATES (GPM)
MAXIMUM WATER LOSS CASE

Time	Parameter	LOCA	S/D
10 – 30 min.	Core Spray (2 loops) Safety Relief valves & RCICS RHRHX (tube side) Flow, Loop A RHRHX (tube side) Flow, Loop B RHRHX (shell side) Flow, Loop A RHRHX (shell side) Flow, Loop B	12,700 N/A 9,000 9,000 10,000 10,000	0 (1) 9,000 9,000 10,000 10,000
30 min. – 30 days	Core Spray (1 loop) RHRHX (tube side) Flow, Loop A RHRHX (tube side) Flow, Loop B RHRHX (shell side) Flow, Loop A RHRHX (shell side) Flow, Loop B	6,350 9,000 9,000 10,000 10,000	0 9,000 9,000 10,000 10,000

Note: (1) The flow rate is determined by the cooldown rate.

(2) LOCA Unit RHR Flow Rates denote the suppression pool cooling mode of operation.

(3) S/D Unit RHR Flow Rates denote two divisions of suppression pool cooling operation for approximately the first three hours of the transient followed by one division of shutdown cooling operation and one division of fuel pool cooling operation for the remainder of the thirty days.

TABLE 9.2-22

EMERGENCY SERVICE WATER SYSTEM FLOW RATES (GPM)

I. Minimum Heat Transfer (MHT) Case		
Time	Loop A	Loop B
0 – 3 hrs.	2186	3043
3 hrs. – 30 days	4974	0.00
II. Maximum Water Loss (MWL) Case		
Time	Loop A	Loop B
0 – Approx. 3 days	6058	4968
Approx. 3 days – 30 days	8040	2985

TABLE 9.2-23

INITIAL CONDITIONS

	Unit 1 (LOCA)	Unit 2 (FORCED SHUTDOWN)
Reactor Vessel		
Temperature, °F	211	551
Water Mass, lbm.	358,000	663,000
RPV Mass, Metal, lbm.	2.49×10^6	2.49×10^6
RPV Specific Heat, Btu/lbm °F	0.11	0.11
RPV Heat Capacity, Metal, Btu/°F	2.74×10^5	2.74×10^5
Drywell Floor		
Temperature, °F	231	N/A
Water Mass, lbm	467,000	N/A
Suppression Pool		
Temperature, °F	156	101
Water Mass, lbm.	7.101×10^6	7.672×10^6
Spray Pond Initial Temperature, °F	85.5° Min. Heat Dissipation Case (1)	

(1) Allows 0.5°F for instrument error.

TABLE 9.2-27

SIZE COMPARISON OF SPRAY PONDS INVESTIGATED

	Canadys	SSES	Rancho Seco
Water Flow Rate, gpm	180,000	55,968 (max)	16,500
Nozzles	1,800 @ 100 gpm	1,056 @ 53 gpm	304 @ 53 gpm
Water Pressure at Nozzle, psig	7	7	7
Pond Length, feet	-	1,250	330
Width, feet		525 to 225	165
Depth, feet	10	10.5	5
Volume (approx.) x 10^6 gallons	32.4	25.0	5.7
Area Acres	10	8	1.3

TABLE 9.2-28

PERFORMANCE COMPARISON OF CANADYS STATION AND MODEL RESULTS

T_{DB}/T_{WB}, °F	T_h, °F	T_c, °F	WS, mph	Meas. Eff., %	Model Eff., %
98/77.8	114	102.85	5.68	35.2 ± 3.47	30.81
75.7/70.9	111	98.91	6.25	34.3 ± 3.13	30.15
78.5/70.4	111	98.08	7.96	37.2 ± 3.09	34.53
71/62.3	97	86.99	8.52	34.6 ± 3.63	28.86
78/65.3	101	92.83	5.11	28.7 ± 3.59	22.87
97/79.7	112	101.75	6.25	35.1 ± 4.07	33.50

T_{DB} = dry bulb temperature

T_{WB} = wet bulb temperature

T_h = hot water temperature before spraying

T_c = sprayed water temperature just before entering pond

WS = wind speed

Meas. Eff. = measured efficiency

Model Eff. = calculated efficiency using model

* The uncertainty ranges were calculated by considering the likely accuracy of the instrumentation.

TABLE 9.2-29

PERFORMANCE COMPARISON OF RANCHO SECO TEST RESULTS AND MODEL RESULTS

Date	Time	T_{WB}, °F	T_{DB}, °F	W.S., MPH	T, °F	Rancho Seco % Efficiency	Model Prediction Efficiency
5/19/73	1424	61.0	81.5	13.0	79.8	41.4	41.35
5/19/73	1615	61.5	81.5	12.5	80.0	47.1	42.62
5/20/73	0400	51.0	55.0	4.9 (5.3)*	77.4	33.9	27.12
5/20/73	0630	48.5	52.0	2.8	77.4	28.8	22.95
5/20/73	1000	56.6 (56.5)*	65.0	6.2 (6.0)*	77.6	30.8	29.65
5/20/73	1148	57.5	71.0	6.2 (6.5)*	78.6	34.7	31.52
5/18/73	1500	72.4	95.0	7.0	80.0	38.3	37.46
5/18/73	1700	69.7	93.0	6.5 (6.6)*	81.1 (81.2)*	36.6	36.55
5/18/73	1900	66.6	85.7	8.5 (8.4)*	80.7	50.8	38.90
5/18/73	2200	60.9	72.3	3.4 (3.8)*	80.1 (80.3)*	33.6	25.56
7/19/73	2300	60.2	69.3	2.6 (3.8)*	79.7	28.5	25.66
5/20/73	2300	54.2	58.0	1.0	101.4	37.4	30.89
5/20/73	2330	53.0	57.0	1.2 (1.6)*	98.5 (100.0)*	36.5	34.13
5/20/73	2400	52.0	56.0	1.2 (1.3)*	97.8 (97.9)*	38.3	31.49
5/20/73	0330	49.0	53.0	1.4 (1.0)*	101.7	36.7	29.75
5/20/73	0415	48.0	51.0	0.80 (0.59)*	97.4	36.1	26.04

* Values in parentheses are the values used in the model prediction.

FIGURE 9.2-1A-1 REPLACED BY DWG. M-109, SH. 1

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SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 9.2-1A-1 REPLACED BY DWG. M-109, SH. 1

FIGURE 9.2-1A-1, Rev. 55

AutoCAD Figure 9_2_1A_1.doc

FIGURE 9.2-1A-2 REPLACED BY DWG. M-109, SH. 2

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UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 9.2-1A-2 REPLACED BY DWG. M-109, SH. 2

FIGURE 9.2-1A-2, Rev. 55

AutoCAD Figure 9_2_1A_2.doc

FIGURE 9.2-1A-3 REPLACED BY DWG. M-109, SH. 3

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UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 9.2-1A-3 REPLACED BY DWG. M-109, SH. 3

FIGURE 9.2-1A-3, Rev. 55

AutoCAD Figure 9_2_1A_3.doc

FIGURE 9.2-1B REPLACED BY DWG. M-110, SH. 1

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UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 9.2-1B REPLACED BY DWG. M-110, SH. 1

FIGURE 9.2-1B, Rev. 53

AutoCAD Figure 9_2_1B.doc

FIGURE 9.2-1C REPLACED BY DWG. M-2110, SH. 1

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FIGURE 9.2-1C REPLACED BY DWG. M-2110, SH. 1 FIGURE 9.2-1C, Rev. 53

AutoCAD Figure 9_2_1C.doc

FIGURE 9.2-2 REPLACED BY DWG. M-113, SH. 1

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UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 9.2-2 REPLACED BY DWG. M-113, SH. 1

FIGURE 9.2-2, Rev. 55

AutoCAD Figure 9_2_2.doc

FIGURE 9.2-3 REPLACED BY DWG. M-114, SH. 1

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UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 9.2-3 REPLACED BY DWG. M-114, SH. 1

FIGURE 9.2-3, Rev. 55

AutoCAD Figure 9_2_3.doc

FIGURE 9.2-4 REPLACED BY DWG. M-131, SH. 1

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UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 9.2-4 REPLACED BY DWG. M-131, SH. 1

FIGURE 9.2-4, Rev. 49

AutoCAD Figure 9_2_4.doc

FIGURE 9.2-5A REPLACED BY DWG. M-111, SH. 1

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SUSQUEHANNA STEAM ELECTRIC STATION UNITS 1 & 2 FINAL SAFETY ANALYSIS REPORT
FIGURE 9.2-5A REPLACED BY DWG. M-111, SH. 1 FIGURE 9.2-5A, Rev. 57

AutoCAD Figure 9_2_5A.doc

FIGURE 9.2-5B REPLACED BY DWG. M-111, SH. 2

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SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 9.2-5B REPLACED BY DWG. M-111, SH. 2

FIGURE 9.2-5B, Rev. 56

AutoCAD Figure 9_2_5B.doc

FIGURE 9.2-5C REPLACED BY DWG. M-111, SH. 3

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SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 9.2-5C REPLACED BY DWG. M-111, SH. 3

FIGURE 9.2-5C, Rev. 51

AutoCAD Figure 9_2_5C.doc

FIGURE 9.2-5D REPLACED BY DWG. M-111, SH. 4

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SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 9.2-5D REPLACED BY DWG. M-111, SH. 4

FIGURE 9.2-5D, Rev. 3

AutoCAD Figure 9_2_5D.doc

FIGURE 9.2-6 REPLACED BY DWG. M-112, SH. 1

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UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 9.2-6 REPLACED BY DWG. M-112, SH. 1

FIGURE 9.2-6, Rev. 51

AutoCAD Figure 9_2_6.doc

FIGURE 9.2-7-1 REPLACED BY DWG. M-117, SH. 1

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SUSQUEHANNA STEAM ELECTRIC STATION UNITS 1 & 2 FINAL SAFETY ANALYSIS REPORT
FIGURE 9.2-7-1 REPLACED BY DWG. M-117, SH. 1
FIGURE 9.2-7-1, Rev. 55

AutoCAD Figure 9_2_7_1.doc

FIGURE 9.2-7-2 REPLACED BY DWG. M-117, SH. 2

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SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 9.2-7-2 REPLACED BY DWG. M-117, SH. 2

FIGURE 9.2-7-2, Rev. 55

AutoCAD Figure 9_2_7_2.doc

FIGURE 9.2-7-3 REPLACED BY DWG. M-117, SH. 3

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SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 9.2-7-3 REPLACED BY DWG. M-117, SH. 3

FIGURE 9.2-7-3, Rev. 55

AutoCAD Figure 9_2_7_3.doc

FIGURE 9.2-7-4 REPLACED BY DWG. M-117, SH. 4

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SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 9.2-7-4 REPLACED BY DWG. M-117, SH. 4

FIGURE 9.2-7-4, Rev. 55

AutoCAD Figure 9_2_7_4.doc

FIGURE 9.2-7-5 REPLACED BY DWG. M-117, SH. 5

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SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 9.2-7-5 REPLACED BY DWG. M-117, SH. 5

FIGURE 9.2-7-5, Rev. 55

AutoCAD Figure 9_2_7_5.doc

FIGURE 9.2-8-1 REPLACED BY DWG. M-118, SH. 1

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SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 9.2-8-1 REPLACED BY DWG. M-118, SH. 1

FIGURE 9.2-8-1, Rev. 55

AutoCAD Figure 9_2_8_1.doc

FIGURE 9.2-8-2 REPLACED BY DWG. M-118, SH. 2

FSAR REV. 65

SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 9.2-8-2 REPLACED BY DWG. M-118, SH. 2

FIGURE 9.2-8-2, Rev. 56

AutoCAD Figure 9_2_8_2.doc

FIGURE 9.2-8-3 REPLACED BY DWG. M-118, SH. 3

FSAR REV. 65

SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 9.2-8-3 REPLACED BY DWG. M-118, SH. 3

FIGURE 9.2-8-3, Rev. 55

AutoCAD Figure 9_2_8_3.doc

FIGURE 9.2-9 REPLACED BY DWG. M-108, SH. 1

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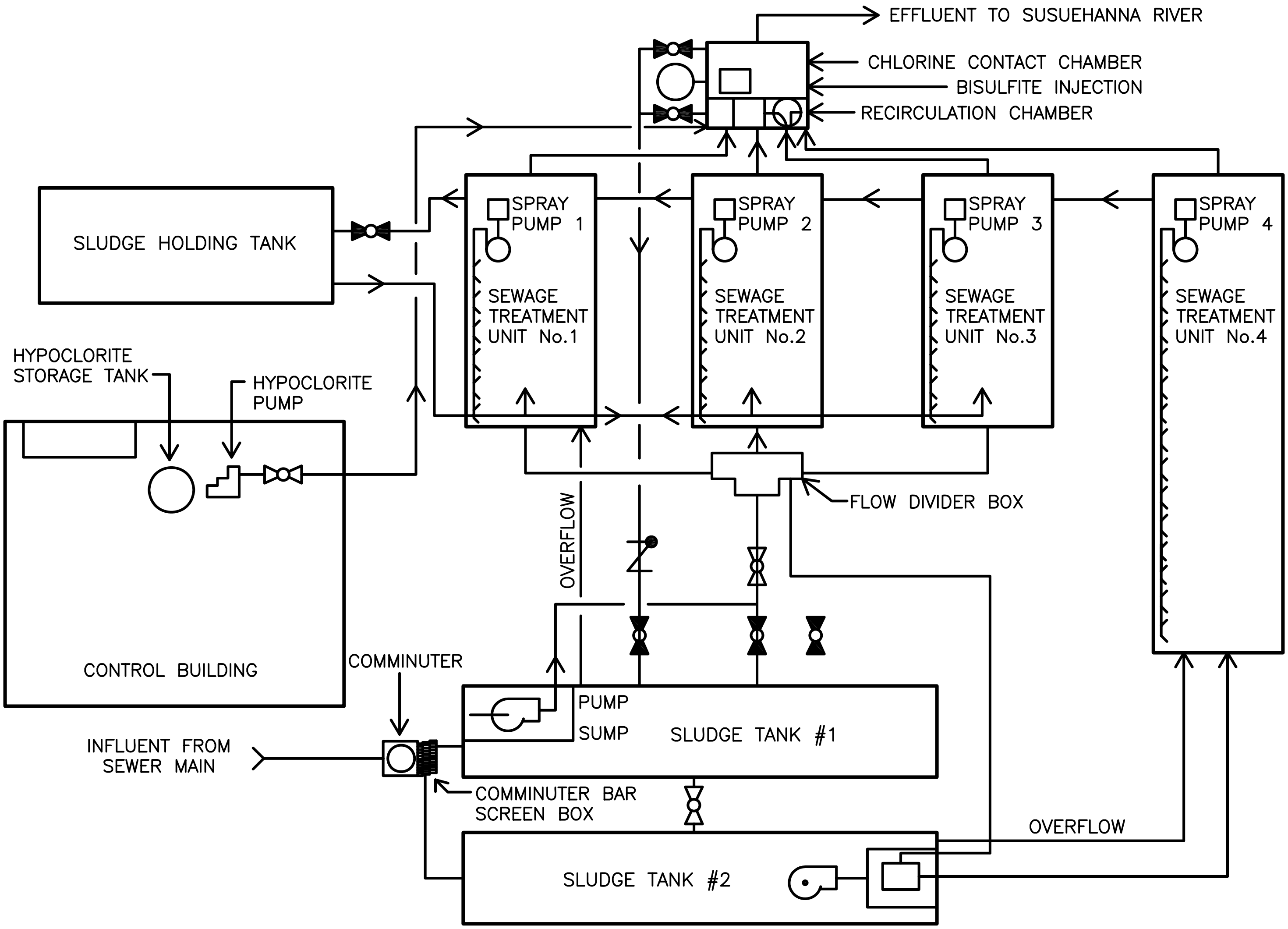
SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 9.2-9 REPLACED BY DWG. M-108, SH. 1

FIGURE 9.2-9 Rev. 56

AutoCAD Figure 9_2_9.doc



NOTE:
TREATMENT PLANT CONSISTS OF THREE 15,000 gpd CAPACITY AND ONE 35,000 gpd CAPACITY EXTENDED AERATION TYPE PACKAGE PLANTS EACH CONSISTING OF AN AERATION TANK AND ONE CLARIFIER. TOTAL PLANT CAPACITY– 80,000 gpd.

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SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

SEWAGE TREATMENT PLANT
FLOWSHEET

FIGURE 9.2-10, Rev 50

AutoCAD: Figure Fsar 9_2_10.dwg

FIGURE 9.2-11-1 REPLACED BY DWG. M-186, SH. 1

FSAR REV. 65

SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 9.2-11-1 REPLACED BY DWG. M-186, SH. 1

FIGURE 9.2-11-1, Rev. 55

AutoCAD Figure 9_2_11_1.doc

FIGURE 9.2-11-2 REPLACED BY DWG. M-186, SH. 3

FSAR REV. 65

SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 9.2-11-2 REPLACED BY DWG. M-186, SH. 3

FIGURE 9.2-11-2, Rev. 55

AutoCAD Figure 9_2_11_2.doc

FIGURE 9.2-12 REPLACED BY DWG. M-188, SH. 1

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SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 9.2-12 REPLACED BY DWG. M-188,
SH. 1

FIGURE 9.2-12, Rev. 48

AutoCAD Figure 9_2_12.doc

FIGURE 9.2-13A REPLACED BY DWG. M-187, SH. 1

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SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 9.2-13A REPLACED BY DWG. M-187, SH. 1

FIGURE 9.2-13A, Rev. 55

AutoCAD Figure 9_2_13A.doc

FIGURE 9.2-13B REPLACED BY DWG. M-187, SH. 2

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SUSQUEHANNA STEAM ELECTRIC STATION UNITS 1 & 2 FINAL SAFETY ANALYSIS REPORT
FIGURE 9.2-13B REPLACED BY DWG. M-187, SH. 2 FIGURE 9.2-13B, Rev. 48

AutoCAD Figure 9_2_13B.doc

FIGURE 9.2-14-1 REPLACED BY DWG. M-189, SH. 1

FSAR REV. 65

SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 9.2-14-1 REPLACED BY DWG. M-189, SH. 1

FIGURE 9.2-14-1, Rev. 55

AutoCAD Figure 9_2_14_1.doc

FIGURE 9.2-14-2 REPLACED BY DWG. M-189, SH. 2

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SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 9.2-14-2 REPLACED BY DWG. M-189, SH. 2

FIGURE 9.2-14-2, Rev. 55

AutoCAD Figure 9_2_14_2.doc

FIGURE 9.2-14-3 REPLACED BY DWG. M-189, SH. 3

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SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 9.2-14-3 REPLACED BY DWG. M-189, SH. 3

FIGURE 9.2-14-3, Rev. 55

AutoCAD Figure 9_2_14_3.doc

FIGURE 9.2-14-4 REPLACED BY DWG. M-189, SH. 4

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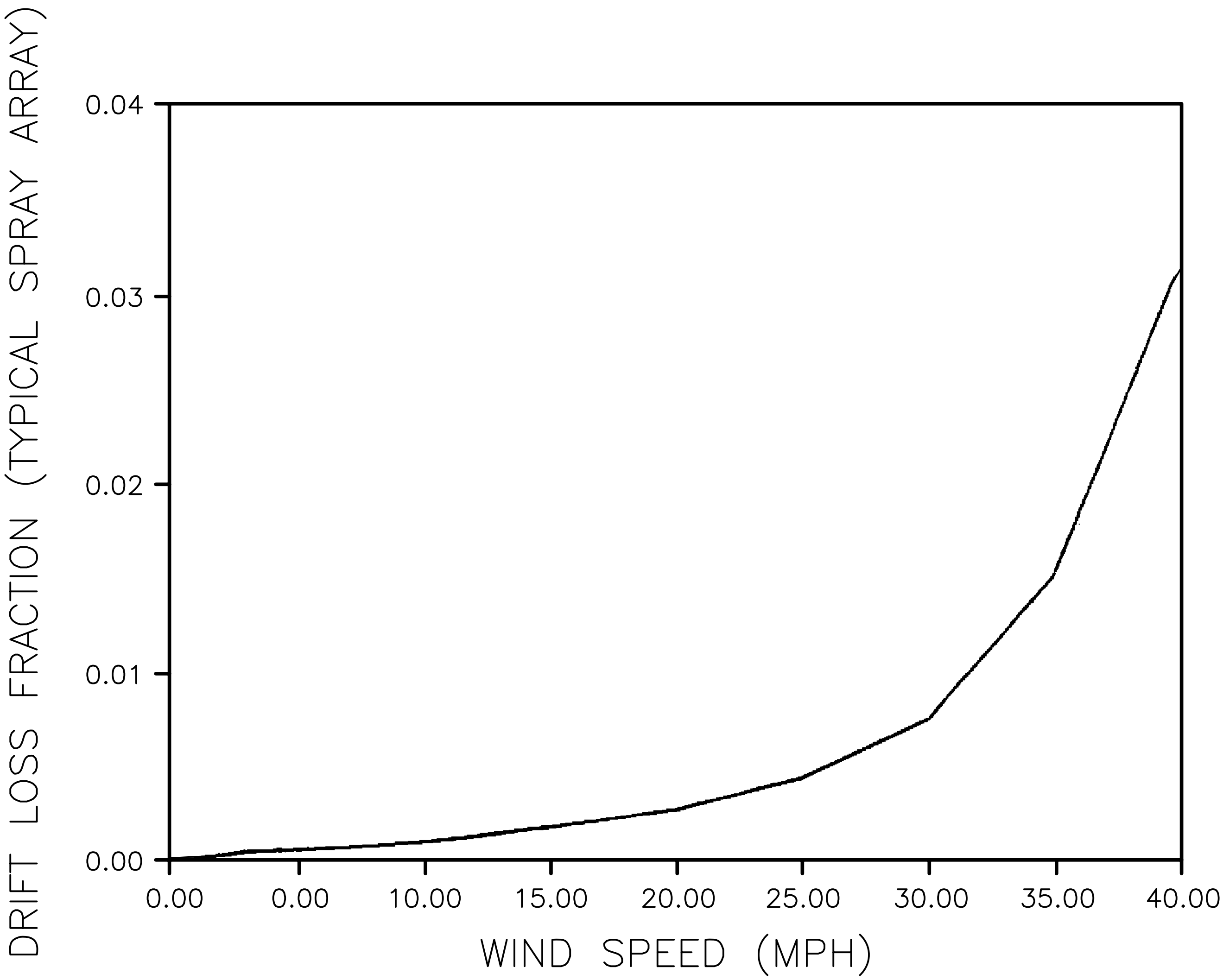
SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 9.2-14-4 REPLACED BY DWG. M-189, SH. 4

FIGURE 9.2-14-4, Rev. 55

AutoCAD Figure 9_2_14_4.doc



NOTE: This curve is representative of a typical array. Actual values used in evaluation of drift losses are based on analytical computations for specific array conditions.

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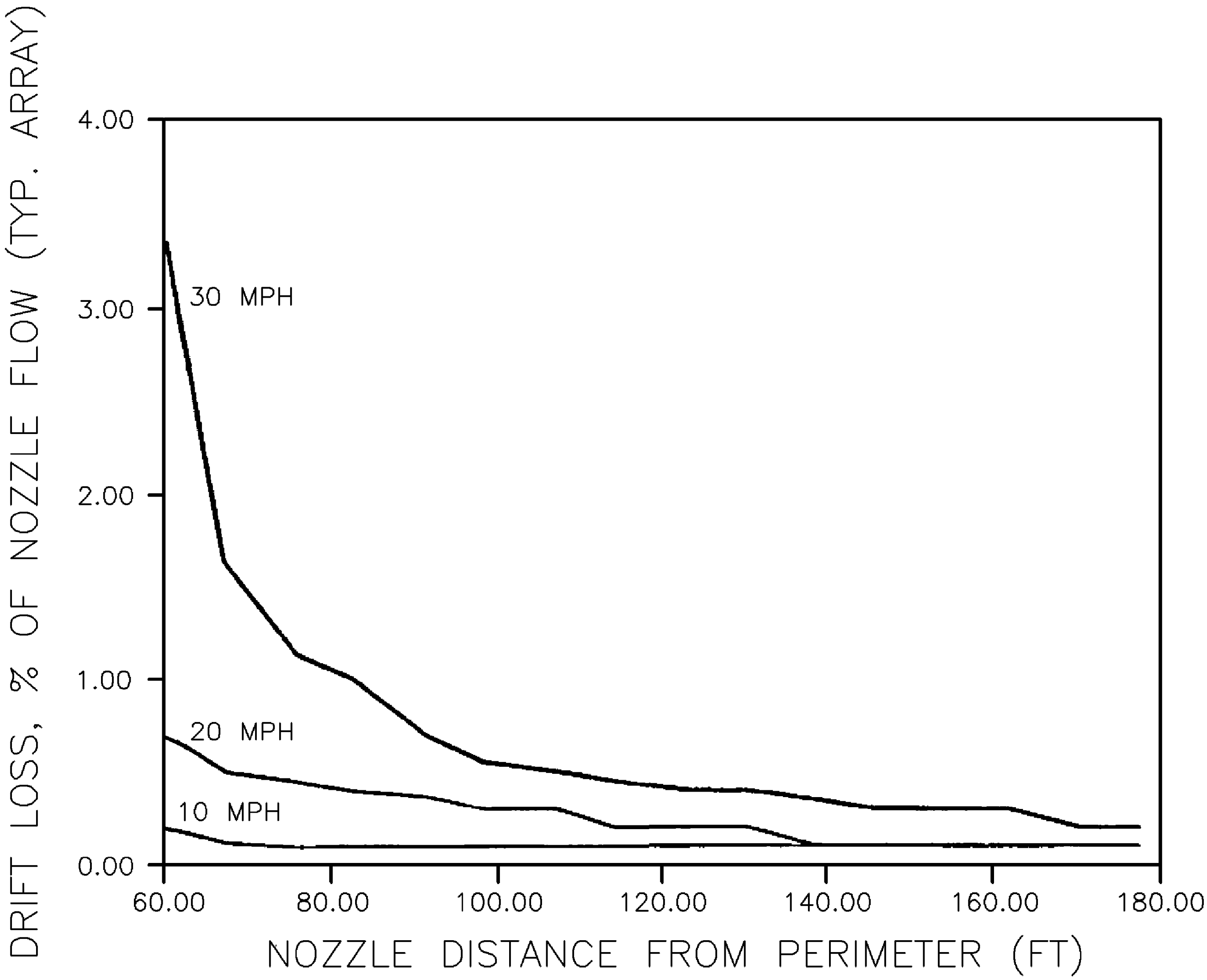
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

DRIFT LOSS
VS.
WINDSPEED

FIGURE 9.2-15, Rev 51

AutoCAD: Figure Fsar 9_2_15.dwg



NOTE: This curve is representative of a typical array. Actual values used in evaluation of drift losses are based on analytical computation for specific array conditions.

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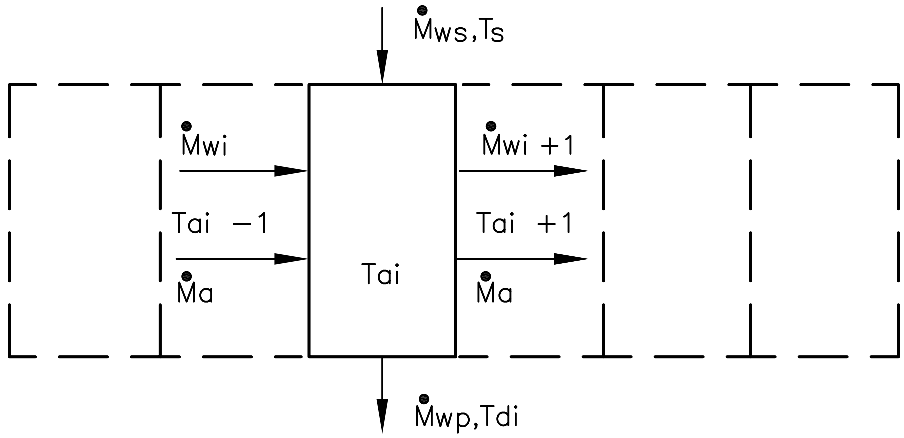
SUSQUEHANNA STEAM ELECTRIC STATION UNITS 1 & 2 FINAL SAFETY ANALYSIS REPORT
DRIFT LOSS VS. PERIMETER DISTANCE FIGURE 9.2-16, Rev 51

AutoCAD: Figure Fsar 9_2_16.dwg



$\dot{M}ws$ = mass flow rate of spray water in increment

$\dot{M}wi$ = mass flow rate of vapor into increment

$\dot{M}a$ = mass flow rate of air

$\dot{M}wp$ = mass flow rate of water into pond

Tai = dry bulb air temperature in increment

Tdi = temperature of water entering the pond

Ts = water temperature at nozzle

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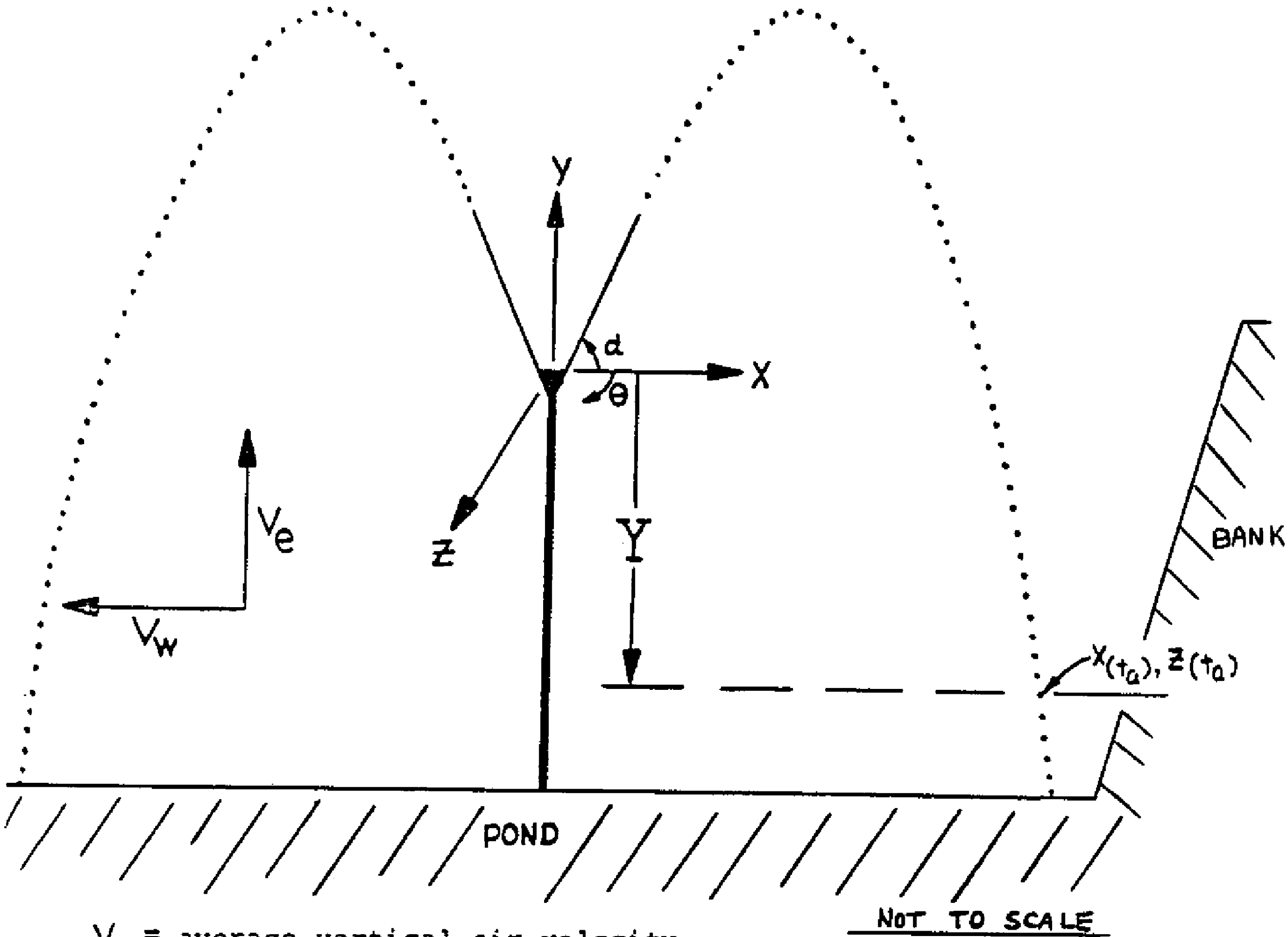
SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

SPRAY POND
INCREMENTAL MASS & ENERGY
FLOW SCHEMATIC

FIGURE 9.2-17, Rev 49

AutoCAD: Figure Fsar 9_2_17.dwg



V_e ≡ average vertical air velocity

V_w ≡ wind velocity

t_a ≡ time for drop to reach elevation necessary for loss

d ≡ angle of departure

Y ≡ elevation of nozzle above elevation necessary for loss

θ ≡ azimuthal angle (used in definition of initial direction)

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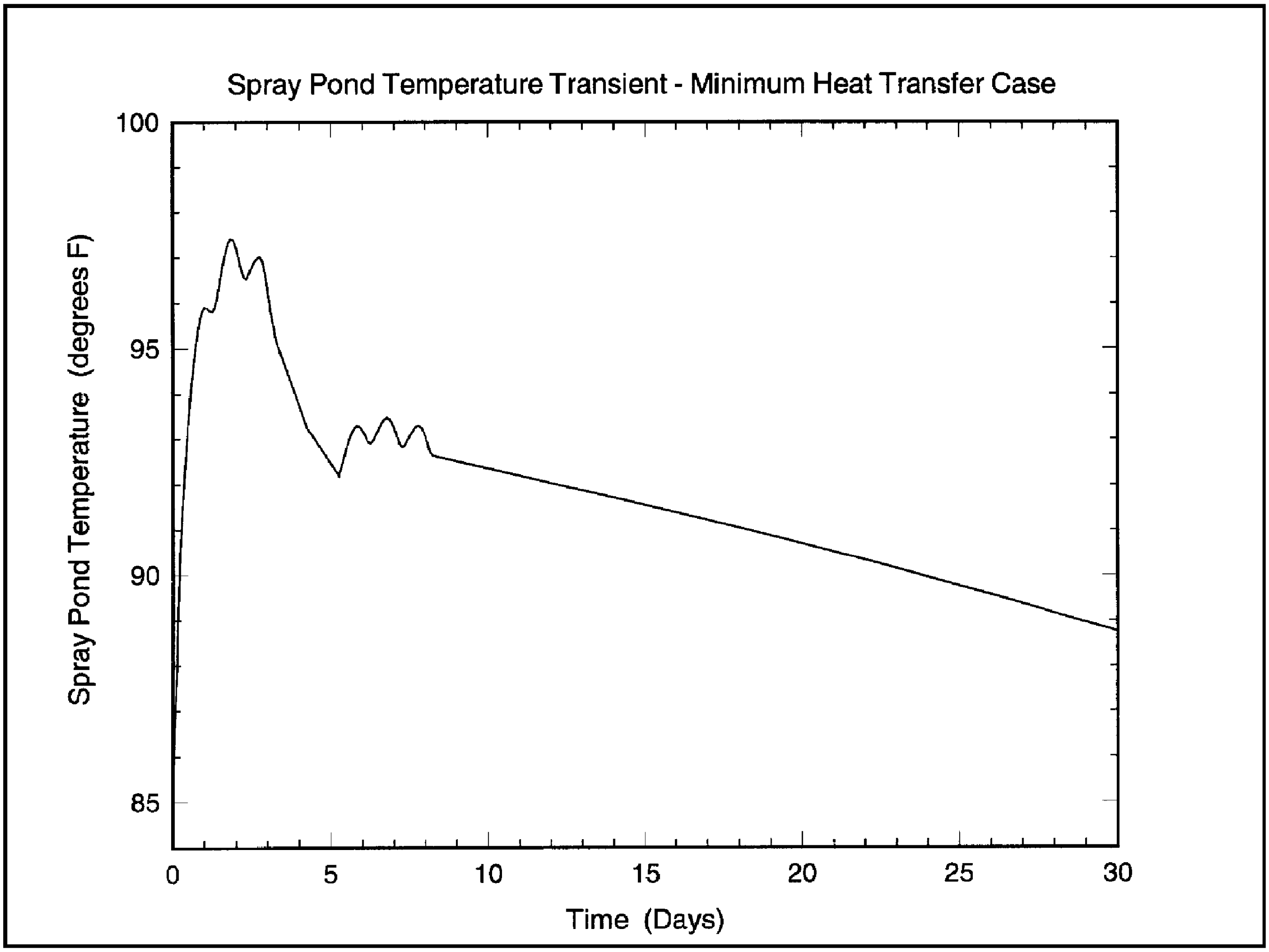
SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

SPRAY POND
DROPLET TRAJECTORY
PARAMETERS

FIGURE 9.2-18, Rev 49

AutoCAD: Figure Fsar 9_2_18.dwg



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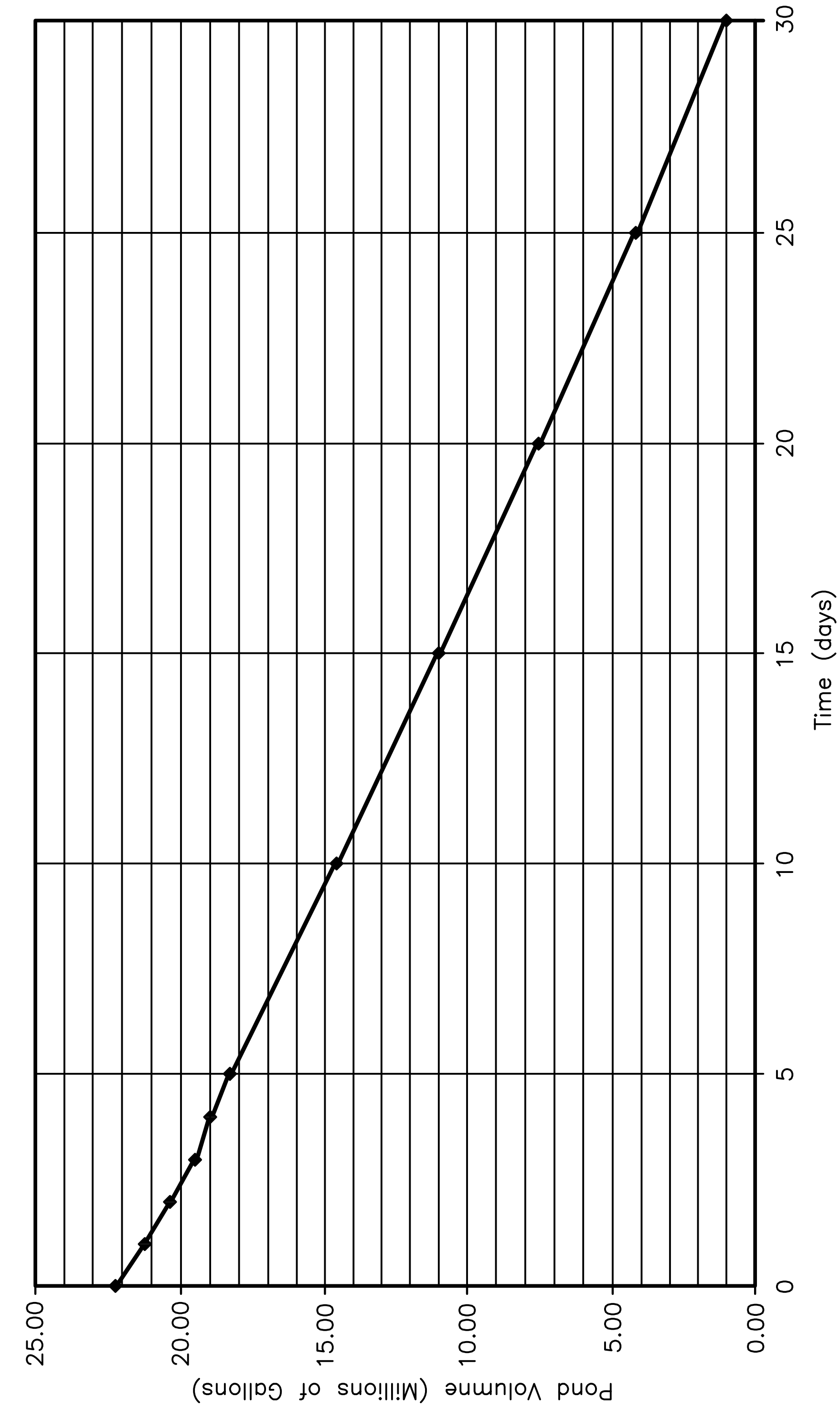
SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

SPRAY POND TEMPERATURE
TRANSIENT MINIMUM HEAT
TRANSFER CASE

FIGURE 9.2-21, Rev 54

AutoCAD: Figure Fsar 9_2_21.dwg



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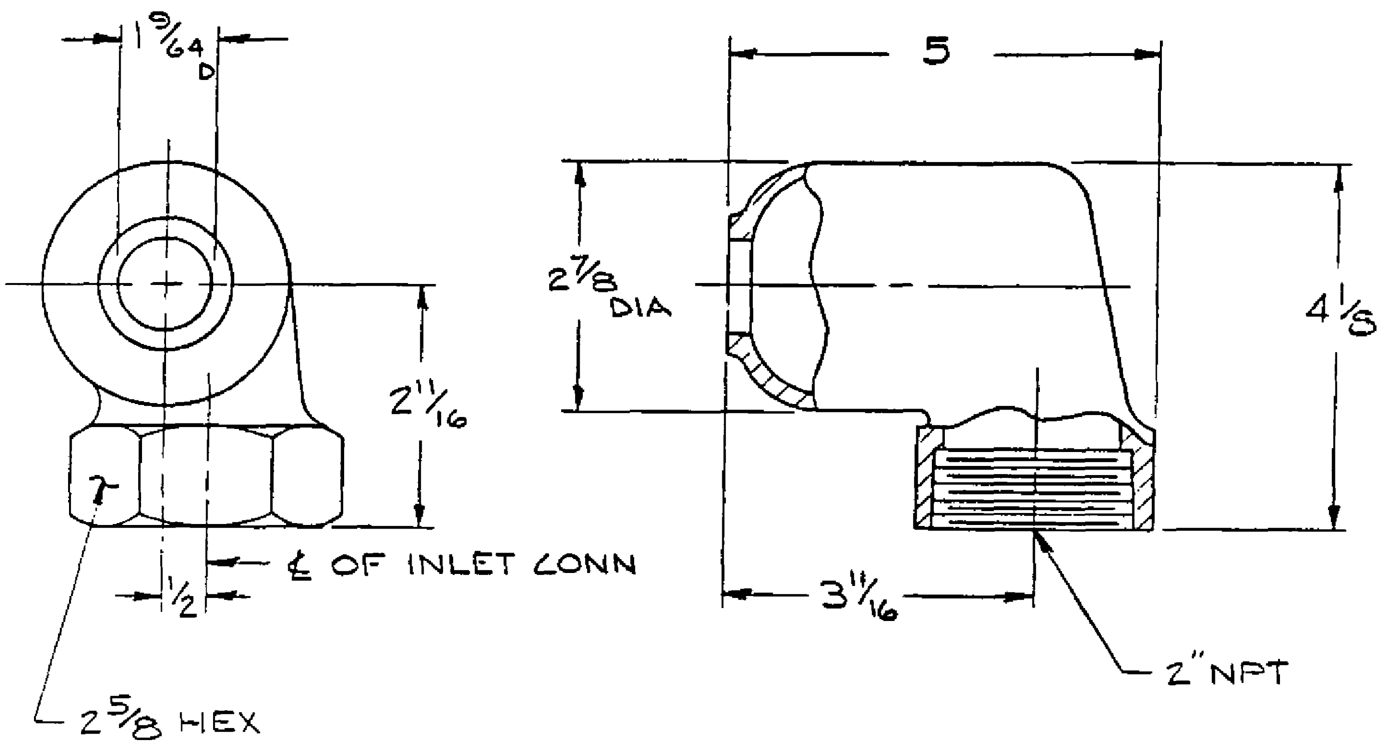
SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

SPRAY POND
WATER INVENTORY
MAXIMUM WATER LOSS CASE

FIGURE 9.2-22, Rev 56

AutoCAD: Figure Fsar 9_2_22.dwg



NOTE: ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED.

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SUSQUEHANNA STEAM ELECTRIC STATION
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FINAL SAFETY ANALYSIS REPORT

SPRAY POND SPRAY NOZZLE

FIGURE 9.2-23, Rev 51

AutoCAD: Figure Fsar 9_2_23.dwg

Security-Related Information
Figure Withheld Under 10 CFR 2.390

SUSQUEHANNA STEAM ELECTRIC STATION UNITS 1 & 2 FINAL SAFETY ANALYSIS REPORT
SPRAY POND PLAN FIGURE 9.2-24-1

Security-Related Information
Figure Withheld Under 10 CFR 2.390

SUSQUEHANNA STEAM ELECTRIC STATION UNITS 1 & 2 FINAL SAFETY ANALYSIS REPORT
ESSW SPRAY POND NETWORK A1 & B1 PLAN, SECTIONS AND DETAILS FIGURE 9.2-24-2

Security-Related Information
Figure Withheld Under 10 CFR 2.390

SUSQUEHANNA STEAM ELECTRIC STATION UNITS 1 & 2 FINAL SAFETY ANALYSIS REPORT
ESSW SPRAY POND NETWORK A2 & B2 PLAN, SECTIONS & DETAILS FIGURE 9.2-24-3