BYRON STATION
UHS DESIGN BASIS RECONSTITUTION
FINAL REPORT
January 9, 1992

EXECUTIVE SUMMARY

An Ultimate Heat Sink Design Bases Reconstitution effort and Operability Assessment process undertaken by Commonwealth Edison Company (CECo) has concluded the UHS meets all the applicable General Design Criteria of 10 CFR 50 Appendix A. The UHS design accident analyses and operation have been determined to be consistent with all relevant Regulatory Guides and design standards committed to in the Byron/Braidwood UFSAR. The capability of the UHS to perform its two principle safety functions has been verified. These safety functions are: 1) dissipation of decay heat energy after reactor shutdown and 2) dissipation of decay heat energy and containment stored heat energy after an accident.

As a direct result of the review, administrative requirements have been imposed until a Technical Specification amendment can be prepared and approved. The administrative limitations assure critical initial assumptions made in the accident analyses are observed in day to day plant operation. The process of reconciling descriptive UFSAR entries with the reconstitution efforts findings is underway. Safety Evaluations will be performed for all permanent changes made to the UFSAR description.

The reconstitution and operability assessment efforts were carried out by a team of individuals which resulted in the integration of the operating experience of station personnel with accident analysis, engineering and licensing knowledge of personnel from CECo's Corporate Offices/Architect Engineer's Staff. The analyses performed as part of the reconstitution effort, as described in this report, have shown that SX cold water basin temperature does not exceed 98°F during normal and potential accident conditions. The evaluation did not result in the need for any hardware modifications to the plant. One minor setpoint value change was made for the high-temperature auto-closure interlock of the bypass valves to the Cooling Tower riser piping. Improvements were made in the normal and emergency operating procedures to provide greater assurance of Essential Service Water Cooling Tower operation consistent with assumptions made in the accident analyses.

I. HISTORICAL BACKGROUND/ INTRODUCTION

In October of 1986, the Essential Service Water Cooling Towers were preoperationally tested as part of the test program for Byron Unit 2. As a result of evaluation of the test data, Commonwealth Edison Company (CECo) determined that additional testing was necessary under more challenging conditions. In a letter to the Nuclear Regulatory Commission dated November 3, 1986, CECo indicated that testing up to that time had demonstrated the capability of the system to handle design basis accident heat loads under limited ambient conditions. CECo proposed procedural restrictions to be in place until the additional tower performance testing could be completed and evaluated. In a January 14, 1987 letter, CECo identified interim administrative controls to be put in place for plant operation until an additional Ultimate Heat Sink (UHS) Cooling Tower Performance test could be completed in the summer of 1987. The letter also committed to providing an evaluation of the performance test. The Commission subsequently placed a License Condition in Attachment 1 to the Byron Unit 2 Full Power Operating License NPF-66 referencing the two previous letters. The License Condition stated that Byron shall comply with the schedular testing commitments of those letters.

On March 24, 1987 CECo submitted an application for amendment of Technical Specifications Section 3/4.7.5d. The requested amendment would allow the 80°F Basin temperature limit to be exceeded without any cooling tower fans running during part of the pending cooling tower performance test. On May 12, 1987, Amendment #8 to the Byron Technical Specifications was issued containing this allowance. On May 26, 1987 CECo provided an analysis to the Commission which stated that previous analyses and operating restrictions on cooling tower operation were overly restrictive. Previous analyses assumed a steady state heat load on the cooling towers due to a Loss of Coolant Accident (LOCA) on one unit and the normal shutdown of the second unit. In actuality, the LOCA heat load peaks at approximately 100 seconds into the transient and then rapidly tapers off to a lower values. If the transient nature of the LOCA heat load and the heat abcorption capability of the water inventory in the Essential Service Water (SX) system are taken into account, then the administrative wet-bulb temperature restriction could be removed and replaced with a temporary operating limit of 90°F on the SX Pump discharge temperature. Upon completion of the Cooling Tower performance test the new administrative limit would be re-evaluated.

On May 29, 1987 two letters were issued to the Commission indicating 4 cooling tower fans were necessary versus the previously indicated 3 fans, to accommodate the design basis accident at the design basis wet bulb temperature. One of the two letters also transmitted the time dependent transient analysis, which supported the 90°F SX pump discharge temperature limit, provided 4 fans are assumed available for heat removal. A scenario leaving only 4 fans operable, while one unit is undergoing a LOCA/LOOP and the second unit is proceeding to a safe shutdown, starts by having only the six fans required operable by Technical Specifications. A single active failure of an Emergency Diesel Generator then caused two of the six remaining operable fans to be non-functional. Therefore, only the four remaining fans were assumed to be available to remove the design basis heat load.

From May 21 to June 4, 1987 Byron Station personnel and Environmental Systems Corporation (ESC) conducted performance testing on the Byron mechanical draft cooling towers. The results were evaluated and transmitted to the Commission on February 1, 1988 as Revision 1 of the "Byron Nuclear Generating Station Essential Service Water Cooling Tower Thermal Performance Test Report." Our intent at that time was to submit a Technical Specification amendment to the Commission to provide assurance beyond the administrative controls already being maintained, that Cooling Tower operation remain within the assumptions made in the report. On April 24, 1989 the Commission issued a Safety Evaluation Report and Technical Evaluation Report concluding that the Byron Essential Service Water Cooling Towers met the Commission's design criteria.

On August 16, 1990 CECo submitted an application for Amendment of the Byron Station Technical Specifications. The proposed amendment affected both Specifications 3.7.4 and 3.7.5. The proposed amendment did following: 1) Changed the maximum basin temperature limit to a single limit of 88°F in combination with additional fan operational requirements, 2) Separated the basin level switch operability requirements from the Essential Service Water Makeup Pumps operability requirements, and 3) Proposed other minor changes of an administrative nature. A meeting was scheduled for March 18, 1991 between CECo and NRR to allow CECo to present the rationale and bases for the proposed Technical Specification Amendment. In preparation for the meeting/presentation CECo personnel met on March 11, 1991.

During the review of March 11, it appeared there may be two assumptions that were used in the calculations of the SX cooling tower heat removal capability that did not reflect actual conditions in certain accident scenarios. In addition, a number of questions remained unanswered regarding the UHS design bases and related analyses. As a result, CECo requested a delay of the NRC presentation. The CECo Nuclear Engineering Department (NED) began drafting an action plan to re-examine the design bases of the UHS and all assumptions of calculations supporting its heat removal capability to eliminate any uncertainty.

The next CECo meeting took place at Byron Station on March 27, 1991. The draft action plan prepared by NED was discussed. Meeting participants concluded that if there were inaccurate assumptions, the effect on the calculations would be offset by the margin available by the seasonal weather conditions, (i.e., the significantly lower wet bulb temperature conditions of early spring relative to the assumed 78°F calculation assumption). The other major point of discussion was to identify the individual tasks of the NED action plan which could be used in a more definitive operability assessment. An April 4th meeting concluded that execution of a design basis reconstitution and operability action plan would likely take until October 1, 1991 and require significant resources.

On April 12, 1991 a three step UHS Operability Action Plan was decided upon to ensure safe and conservative operation of the SX cooling towers for the spring and summer of 1991. While the design bases reconstitution effort and final operability assessment were underway, two interim operability assessments were to be performed using the NED operability determination procedure ENC-QE-40.1, prior to a final operability assessment determination.

The first ENC-QE-40.1 assessment (Ref. 4 and 6), which was completed by NED on April 15th, addressed the two questionable assumptions made in the original analysis. This interim operability assessment was to remain valid until June 1, 1991, by which time a more detailed operability assessment could be performed. The next assessment would bound operation of the Byron units during the time of the year which would present the greatest challenge to the cooling tower's heat removal capability under design basis accident conditions. By letter dated April 23, 1991, CECo withdrew its proposed amendment application to modify the UHS Technical Specifications. It was decided resubmittal of the proposed amendment should occur after the Design Basis Reconstitution of th[illegible] UHS.

A second interim operability assessment was completed using ENC-QE-40.1 (Ref. 5 and 7), on June 1, 1991. This assessment provided a basis for summer operation of the cooling towers. The Nuclear Engineering Department issued guidance to Byron Station as a part of this assessment to assure conservative operation of the SX system cooling towers during the summer until the final operability assessment could be performed in the fall of the year.

The final operability assessment (Ref. 11) was completed on November 1, 1991 and was subsequently onsite reviewed. It involved a complete reconstitution of the inputs, assumptions and applicable design bases for the UHS. As a result of this final assessment, long term administrative requirements were imposed and normal/emergency operating procedures were improved.

An inter-disciplinary team performed each of the operability assessments subsequent to the initial assessment, integrating the operating experience of station personnel with the accident analysis, engineering and licensing knowledge of personnel from CECo's Corporate Offices/Architect Engineer's Staff. The team generally met on a bi-weekly basis between May of 1991 and January of 1992. This report [illegible]as produced by the team members and precedes a resubmittal of an applicatio[illegible]r amendment to the Technical Specifications for the UHS.

To en[illegible]e reader of this report to more easily understand what follows, a brief desc[illegible] of the Ultimate Heat Sink design is presented here. The Ultimate Hea[illegible] consists of two Essential Service Water Cooling Towers and the normal make[illegible] safety related makeup and backup makeup systems. Two simplified gener[illegible]rangement drawings are provided as Figures 1 and 2 in Appendix D. The drawings depict the tower design and its interconnections with the rest of the Essential Service Water System. Each of the two safety related mechanical draft Cooling Towers consists of a water storage basin, four fans, four riser valves and two bypass valves. Normal makeup to the Cooling Towers is provided from the non safety-related Circulating Water system, with the safety-related emergency supply of makeup water provided by the Diesel-Driven SX Makeup Pumps located in the River Screen House. The Diesel Driven SX Makeup Pumps auto-start on a low level in the basins. Loss of both the normal and safety-related makeup pumps due to natural phenomena such as a tornado, flooding or loss of SX Makeup Pump suction (due to a seismic event concurrent with low river flow) can be circumvented by use of the backup deep-well makeup pumps.

II. UHS RECONSTITUTION SCOPE

Introduction:

The scope of the operability assessment and design basis reconstitution efforts was initially limited to those facts about the UHS for which either the design basis was known to be incorrect or uncertain enough to warrant review. However, the process remained flexible since the scope of the review was allowed to broaden when discrepant items were identified.

As part of the 1991 reconstitution of the Ultimate Heat Sink design basis for Byron Station, several items were identified as being indeterminate or different from those previously assumed in the UFSAR and design analyses. These items affect the calculated performance of the SX cooling towers during a postulated design basis accident. Extensive design review and reanalysis was required to determine the cumulative effect of the following five items on SX tower calculated cold water basin temperature.

1. The first item is the verification of the licensing design basis requirements for the Byron Station UHS. The regulatory requirements were reviewed to determine the limiting design basis event and the number and type of postulated equipment failures.

2. The second item is an increase in the non-LOCA unit's calculated steady state heat load, from the previously assumed 24×10^6 BTU/hr (24 MBTU/hr) depicted in UFSAR Figure 9.2-7 and derived from UFSAR Table 9.2-6 in previous UHS performance calculations.

3. The third item is an increase in the calculated rate of energy transport from the LOCA unit containment into the Essential Service Water (SX) System via the Reactor Containment Fan Coolers and Containment Recirculation Sump/RH Heat Exchangers/CC Heat Exchangers as shown in UFSAR Table 9.2-6.

4. The fourth item regards statements relating to the assumed worst case wet bulb temperature (Twb) for the cooling tower. UFSAR Section 9.2.5 refers to the design basis as 78°F Twb, while Byron UFSAR Section 2.3 states that 82°F Twb is the meteorological design basis.

5. The fifth item is that the Essential Service Water flows previously assumed are different from the operationally observed values. The flow used in previous analyses assumed 48,000 gpm flowing to a single tower from two SX pumps.

II. A. Byron UHS Design Bases

Design Requirements

The Byron Ultimate Heat Sink (UHS) was designed to satisfy the requirements of the following applicable General Design Criteria (GDC) of 10CFR 50, Appendix A:

2 - Design bases for protection against natural phenomena
4 - Environmental and dynamic effects design basis
5 - Sharing of structures, systems, and components
17 - Electric power systems
38 - Containment heat removal
44 - Cooling water
45 - Inspection of cooling water systems
46 - Testing of cooling water systems

Since the Byron Ultimate Heat Sink is shared by the two units, the condition of both must be determined for the design basis event. Appendix A of the UFSAR indicates commitment to Regulatory Guide 1.27, Rev. 2 - 1976 "Ultimate Heat Sink for Nuclear Power Plants" with no exceptions. It states in part, "Also, in the event of an accident in one unit, the sink should be able to dissipate heat for that accident safely, to permit the concurrent safe shutdown and cooldown of the remaining units, and to maintain all of them in a safe shutdown condition." The Standard Review Plan, NUREG 0800 Rev. 2 - July, 1981 (Section 9.2.1 - Station Service Water System) states the NRC reviewers should conclude in their evaluation that, "The applicant has met the requirements of GDC 5 with respect to sharing of structures, systems, and components by demonstrating that such sharing does not significantly impair its safety function, including in the event of an accident in one unit, an orderly shutdown and cooldown of the remaining units". GDC 5 itself uses nearly identical wording. Byron SER, Section 9.2.5 uses different wording referring to "safe shutdown" or "normal shutdown" of the non-accident unit in two separate instances.

Limiting Design Basis Event and Basis for Assumptions

For design purposes the worst case accident scenario considered for the Byron Station UHS is a LOCA coincident with a Loss of Offsite Power (LOOP) on one unit, and the concurrent orderly shutdown and cooldown from maximum power to Mode 5 of the other unit using normal shutdown operating procedures. This scenario also includes a single active failure.

The choice of LOCA as a worst case accident is in compliance with the guidance provided in the Standard Review Plan (SRP) used in the evaluation of Byron Station design and is in agreement with NRC Reg Guide 1.27, Revision 2, which requires the removal of heat resulting from the limiting design basis event. The LOCA will produce the most limiting heat input to challenge the UHS heat dissipation capabilities.

II. A. Byron UHS Design Bases (Continued)

The coupling of initiating event (LOCA) with a coincident loss of offsite power on the LOCA unit only, is consistent with industry practice for multi-unit sites and ANSI/ANS 51.1 - 1983, "Nuclear Safety Criteria for the Design of Pressurized Water Reactor Plants". It is also consistent with GDC 17, which was utilized in the design of Byron Station systems.

The intent of the guidance given for the Ultimate Heat Sink heat dissipation capability design basis is to require a shutdown of the non-accident reactor by reducing power to zero, placing the reactor in a subcritical condition, and decreasing coolant temperature to ultimately achieve Cold Shutdown conditions (Reactor Coolant System temperature <200°F). Additional heat load is placed on the SX system and UHS once Residual Heat Removal (RHR) is placed in operation at approximately 350°F.

Under normal conditions the minimum time to reach this condition, assuming an orderly shutdown and cooldown from maximum power using normal operating procedures, would be a total of eight hours. It would take approximately four hours to place the unit in Hot Standby at 557°F from full power conditions, and an extremely conservative additional four hours to cooldown the RCS from 557°F to 350°F. Considering the likely initial time delay in initiating a shutdown of the non-accident unit, competition for human resources with the LOCA unit undergoing recovery and the relatively low priority of cooling down the non-accident unit from a stable Hot Standby Condition, it would be a reasonable assumption that the non-accident unit would not achieve Hot Shutdown Conditions of 350°F for 10 to 12 hours.

The selection of credible single failures was limited to single active failures. The selection of single active failures was based on guidance from IEEE Standards, the Byron Safety Evaluation Report-1982 (Section 9.2.5) and SRP Section 9.2.5. Section 9.2.5 of the SRP specifies that the NRC reviewer verify the UHS cooling tower design mechanical systems (fans, pumps, and controls) can withstand a single active failure in any of these systems, including failure of any auxiliary electric power source.

In summary, the limiting design basis event for the Byron Station Ultimate Heat Sink is a Loss of Coolant Accident coincident with a Loss of Offsite Power on one unit, in conjunction with the other unit proceeding to an orderly shutdown and cooldown from maximum power to Mode 5. This UHS accident scenario should also include the effect of a single active failure. This particular series of initiating event, coincident event, and single active failure is consistent with regulatory requirements and with the design basis event presented to the NRC in a May 29, 1987 letter from K.A. Ainger (CECo) to H.R. Denton (NRC).

II. B. Increase in Steady State Heat Load

The previous steady state heat load from two units was 67 MBTU/hr (24 MBTU/hr for the non-LOCA Unit plus 43 MBTU/hr for the LOCA Unit). The new steady state heat load from two units is 103 MBTU/Hr (72 MBTU/hr for the non-LOCA Unit plus 31 MBTU/hr for the LOCA Unit). This results in a greater demand on the SX Cooling Towers. The towers must accept and dissipate more steady state energy than previously assumed. The steady state heat load of 103 MBTU/hr was utilized in the calculations. The total energy rejection must be considered, since this steady state energy is added as a baseline to the LOCA Unit Containment heat load which is varies with time.

II. C. Increase in LOCA Unit Containment Heat Load

Several changes were made in the analysis assumptions which resulted in an increased rate of energy transport into the SX system from the LOCA Unit Containment. A review of the UFSAR containment integrity calculations indicates that the highest heat loads occur for the RCS Double Ended Pump Suction Break with maximum safety injection.

Previous analyses assumed 3 RCFC's and 1 Containment Spray (CS) Pump operating. This was conservative in the sense that it combined this en[illegible] input failure assumption with a coincident loss of heat dissipat[illegible] apability (failure of two SX fans to operate). No single active fa[illegible] could result in 3 RCFC's running and 2 disabled SX fans.

In contrast, this reconstitution study maximized the accident unit containment heat load to the UHS by:

- Postulating scenarios with 4 RCFC's and either 1 or 2 CS pump(s) operating,
- Assuming higher SX water flowrates to the RCFC's,
- Assuming higher air flowrates to the RCFC's, and
- Assuming earlier switchover to Containment Recirculation phase and correspondingly earlier RHR heat loads with 2 CS Pumps operating, consistent with the design of ECCS recirculation.

II. C. Increase in LOCA Unit Containment Heat Load (Continued)

The 4 RCFC's/2 CS pump case, in combination with the other changes above resulted in greater LOCA Unit Containment integrated heat loads of approximately 25% for the first two hours after accident initiation and an increase in LOCA Unit Containment peak heat load from 513 to 830.8 MBTU/hr. These increased heat loads were used for conservatively evaluating UHS Tower performance and do not affect previous UFSAR Chapter 6 containment analyses.

NOTE: The Total Heat Load = LOCA Unit Containment Heat Load + Steady State Heat Load (ex. for the 4/2 Case 830.8 + 103 = 933.8 MBTU/hr)

The 4 RCFC's/1 CS pump case also resulted in greater LOCA Unit Containment integrated heat loads of approximately 25% and an increase in LOCA Unit Containment peak heat load from 513 to 841.6 MBTU/hr. However, the 4/2 case does result in a slightly higher integrated heat load than the 4/1 case.

As a result of increases in the total heat load to the towers, the analysis was also expanded to include the effects of increased evaporation from the SX Towers.

II. D. Wet Bulb Temperature Increase

1. The design conditions for the UHS were specified in the Byron UFSAR Section 9.2.5 as 78°F Twb, but Section 2.3 states the meteorological design basis is 82°F Twb.

   The UFSAR values of 78°F Twb and 82°F Twb are both correct in specific contexts. The actual "design operating" wet bulb temperature of the UHS is 78°F (1% exceedance value) as supported by ASHRAE (Ref. 16). The worst case meteorological wet bulb temperature for the Byron Station area is 82°F for a 3 hour period, as determined in the UFSAR 30 year climatological record search.

   It is at this 82°F wet bulb which Regulatory Guide 1.27 states the UHS must be capable of performing its cooling function for the critical time period (i.e. during the design basis event LOCA/LOOP on one unit/Non-LOCA Unit Shutdown). The effect on the Cooling Tower's ability to reject the design heat loads was considered for the reconstitution analyses utilizing the higher wet bulb temperature of 82°F. The effect of raising the wet bulb temperature was a resultant decrease in the cooling tower performance.

2. In addition to the primary analysis cases, scenarios were developed with the Tower Bypass Valves assumed open.

The bypass valves are typically opened manually in cold weather. For normal operation, the bypass valves auto- open at 52°F decreasing temperature and auto- close at 70°F increasing temperature. These interlocks help protect the tower fill section from freezing. Calculations performed for tower bypass operations utilized a 70°F Twb, corresponding to the tower bypass valve interlock setpoint.

II. E. <u>Changes in Cooling Tower Flowrates</u>

The previous analysis assumed 48,000 GPM flow from 2 SX pumps to a single tower with 4 cells operating and each cell receiving an equivalent share of the total flow. In April, 1991, Byron Station performed Special Procedure #91-008 (Ref. 2) to measure SX flows and pressures under 8 different system configurations. Sargent and Lundy utilized this plant specific data to benchmark the SX FLOSERIES computer model (Ref. 18). After the calibration was performed, the model was run to predict individual tower cell flows and major SX branch flows for each of the postulated single failure scenarios. The reconstitution calculations used these predicted flows (Ref. 19) to account for the change in tower performance with respect to changes in flow.

<u>Summary of Effects of Reconstitution Changes</u>

Extensive evaluation was required to determine the cumulative effect of these five items on the SX tower cold water basin temperature. The analyses performed as part of the reconstitution effort, as described in Section III, have shown that SX cold water basin temperature does not exceed the Technical Specification value of 98°F during normal and potential accident conditions.

III METHODOLOGY AND ANALYSES

Introduction:

This section presents an overview of the methodology and analyses undertaken in the evaluation of the five identified items of concern as they relate to the performance of the UHS cooling towers under accident conditions. Starting with a LOCA and LOOP on one unit, accident scenarios were constructed by invoking single active failures on critical systems or components that were either part of, or interfaced with, the UHS/ESW system. For each scenario, system flows, total heat loads, and steady state performance for individual towers were determined. These inputs were then incorporated into a global time-dependent model of the cooling towers which yielded a prediction of the basin temperature as a function of time.

III. A. Scenario Development and Initial Assumptions/Conditions

The scenario development was a team effort among several Commonwealth Edison Company departments including Operating, Technical Staff, Regulatory Assurance, Project Management, Nuclear Fuel Services, Nuclear Engineering (Systems and Mechanical/Structural) and Nuclear Licensing. Sargent & Lundy Engineers, Westinghouse Electric Corporation and a consultant also participated in the scenario development. The scenarios developed are consistent with the design basis described in Section II.A "Byron UHS Design Basis" of this report.

Various single failure scenarios were analyzed. These scenarios each postulate a LOCA as the initiating event coincident with a LOOP on the LOCA unit plus a single active failure. In addition, the non-accident unit proceeds to an orderly shutdown and cooldown from maximum power to mode 5 using normal shutdown operating procedures. Typically, two sets of initial conditions for each single failure scenario were analyzed since Technical Specification 3.7.5 and plant administrative controls require all available SX tower fans to be running in high speed when the SX tower cold water basin temperature is greater than 80°F. Below 80°F no fans are required to be operating in high speed.

The following conditions were considered for each single active failure analyzed at the limiting 82°F wet bulb temperature.

1. Initially the essential service water system was assumed to be aligned in the normal operating configuration of one pump operating per unit, the pump discharge train crosstie valves open, the unit crosstie valves closed and the return header crosstie valves open. The normally operating heat exchangers and coolers were assumed to receive flow.
2. Cooling tower cold water basin level was assumed to be at the Technical Specification minimum of 50%. This provides the minimum available volume for the SX system to serve as a heat sink. Basin levels above 50% provide additional volume that would increase the heat load capacity of the SX system and result in a lower peak basin temperature.

III. A. Scenario Development and Initial Assumptions/Conditions (Continued)

3. Administrative controls for the UHS require unit shutdown if the tower cold water basin temperature is over 88°F. Therefore, no analyses were performed assuming initial cold water basin temperatures above 88°F.
4. It was assumed that two cooling tower cells were initially out of service and the corresponding riser valves were closed since current requirements of Technical Specifications allow this. Consistent with administrative controls, these cells were assumed to be powered from different units' power supplies. The scenarios considered either one cell out of service on each tower or two cells out of service on one tower, depending on whichever was the most limiting.
5. It was assumed that the tower bypass valves were closed initially.
6. Administrative controls require at least six tower fans running on high speed when the basin temperature is greater than or equal to 80°F. In these scenarios, credit for UHS heat removal was credited immediately following the event since the remaining fans would auto-reenergize with the respective Diesel Generator output breaker auto-closure.
7. Administrative controls do not require any fans running on high speed when the basin temperature is less then 80°F. Therefore, the single failure scenarios were analyzed assuming an initial basin temperature of 80°F and assuming no fans were initially running. These scenarios did not take credit for UHS ambient heat dissipation until post LOCA operator actions were initiated to open riser valves and start fans.
8. When operator actions were required in the Main Control Room, it was assumed these actions occurred 10 minutes following safeguards signals. This caused a ten minute delay before heat removal via the fans begins. The 10 minute delay allowed the Main Control Room operator to reach the applicable step in the Byron Emergency Procedures. This was a reasonable assumption, because all actions are achievable from within the control room and no local operator action is required.
9. The two essential service water pumps on the accident unit were assumed to operate following the LOCA based on auto-start signals, unless the single active failure prevented one pump from starting. The non-accident unit pump that was running initially was assumed to remain running. It was assumed that only one non-accident unit SX pump was running in the post accident modes since the non-running pump would not receive an auto-start signal.
10. All safety related essential service water system heat exchangers and coolers were assumed to be aligned for service based on ESF signals in the post-LOCA condition.

Similar conditions were considered for cool weather operation with the following exceptions:

1. It was assumed that tower bypass valves are initially open for the cool weather scenarios.

2. When operator actions are required locally, it was assumed these actions can be initiated 30 minutes following safeguards signals.

While a wide variety of single active failures can be postulated, scenarios were constructed which fall into one of three categories:

a. Heat Input to the SX System affected
b. Heat Removal by Cooling Tower affected
c. Heat Input and Heat Removal affected

The individual scenarios, as documented in References 12 and 17, detailed the various initial flow alignments, fans out of service, and single active failures. For each scenario an analysis case was developed. The analysis case described the initial conditions, the flow distribution, the energy transport load set, and the available equipment.

Containment Spray Pump Failure
The single failure of a containment spray pump was chosen to maximize the peak heat load on the UHS. This failure maximized the peak heat removal rate by the four operating RCFC's, however, the UHS towers were not functionally affected by this failure.

Cooling Tower Fan Failure
The single failure of a tower fan affects the heat removal capability of a tower. This failure was considered in addition to the two cells that were assumed to be out of service initially. The accident unit containment heat load on the UHS for this failure corresponds to that generated from 4 RCFC's and 2 containment spray pumps operating.

Diesel Generator Failure
The single failure of an emergency diesel generator affects UHS heat load, system flows and tower function. The accident unit containment heat load on the UHS for this failure corresponds to that generated from 2 RCFCs and 1 containment spray pump operating. The SX system flows correspond to one SX pump operating on each unit. In addition to the 2 out of service cells, 2 additional cells were affected by the diesel failure.

Essential Service Water Pump Failure
The single failure of an accident unit essential service water pump reduces overall system and tower flow rates. The towers were not functionally affected by this failure. The accident unit containment heat load on the UHS for this failure corresponds to that generated from 4 RCFCs and 2 containment spray pumps operating.

Other failures considered result in either lower heat input to the tower or did not affect tower heat transfer capability or were enveloped by the above limiting failures.

These scenarios provided the basis for SX system flow and tower cell flow calculations, containment mass/energy release calculations, tower performance calculations and the overall basin temperature calculations summarized in the following sections.

III. B <u>System Hydraulic Calculations</u>

Scenario specific SX flows were calculated (Ref. 19 and 20) for each particular set of postulated accident events (Ref. 12 and 17) for summer and cool weather operation. CECo contracted Sargent and Lundy Engineers to utilize their FLOSERIES computer model (Ref. 18) to determine SX pump, total tower, and individual tower cell flow rates.

The FLOSERIES model was calibrated to more accurately predict actual Essential Service Water system flow and pressure conditions, obtained during Byron Station Special Procedure SPP #91-008. The FLOSERIES calibration was performed using the two SPP test cases that most closely represented a post LOCA SX system configuration. The calibrated model was utilized to analytically predict flows for each of the remaining SPP test cases. The predicted flows were compared to SPP measured flows to confirm the FLOSERIES analytical prediction accuracy. The calibrated FLOSERIES model was used as the basis for additional calculations to predict flows for various postulated accident scenarios.

The FLOSERIES computer runs yield the flows to the major components (RCFC's and CC Heat Exchangers) and flows through the individual tower cells. The results of the computer runs for summer operation show typical tower cell flowrates range from 7,000 to 16,000 gpm/cell. It should be noted that this range of predicted tower flows differs from the previously assumed value of 12,000 gpm/cell, which was derived from the total of 48,000 gpm evenly distributed to four cells. For cool weather operation with the bypass valves open, tower cell flows ranged from zero to 11,400 gpm/cell.

These predicted flows were then used by CECo as input to the UHS performance calculations.

III. C. Containment Heat Load Calculations

The containment heat load calculations (Ref. 14) examined the impact of containment heat removal equipment availability and its impact on the ultimate heat sink. In particular, the Reactor Containment Fan Coolers (RCFC) formed a major portion of the duty of the heat sink during postulated LOCA scenarios. The analysis examined various LOCA cases with respect to equipment availability to generate a series of RCFC heat removal rates versus time data using the CONTEMPT4/MOD5 code. This code has been used extensively throughout the industry and is recommended for use for containment analysis in the Standard Review Plan.

The mass/energy release data used was for the Double Ended Pump Suction LOCA cases with maximum and minimum safety injection capabilities as used in the containment integrity calculations of the UFSAR. However, these analyses differ from the containment integrity cases given in Section 6 of the UFSAR in that the heat removal rates via the RCFCs and RHR systems were maximized to predict a limiting heat load on the UHS. The RCFC performance was recalculated to bound maximum expected SX flow rates and air flowrates. The mass and energy release information was adjusted to incorporate RHR heat removal rates, calculated by Westinghouse, (Ref. 21) during the recirculation phase. The cooling loads generated were used by NED to determine UHS performance during LOCA conditions.

III. D. Steady State Tower Performance Analyses

Cooling tower performance is dependent upon the three parameters; ambient wet bulb temperature, heat load, and water/air flow rates. In turn, values for each of these are dictated by features of the specific accident scenario under evaluation. This section describes the program undertaken by CECo to determine the performance of the Byron UHS cooling towers under the postulated accidents discussed above.

The heat transfer model used to evaluate and predict the performance of these cooling towers was derived from the Merkel theory developed in 1925, as modified by M.R. Lefevre in 1984 (Reference 22). As water passes through the fill region of the tower it is dispersed into a large number of small droplets so as to maximize the heat transfer surface area. Merkel assumed that at a given elevation in the tower each water droplet has a uniform temperature and is surrounded by a film of fully saturated air at the same temperature. Heat is transferred from the water primarily by evaporation from the film into the air. Additionally, because the air is cooler than the water, some degree of sensible heat transfer takes place as well. Using several approximations Merkel showed that the total rate of heat transfer was proportional to the droplet-film to air enthalpy difference. This relationship was then incorporated into an integral, referred to as the demand integral, which could be used directly to evaluate tower performance.

M. R. Lefevre's contributions improved upon the earlier approximations with the end result that more accurate and conservative predictions of tower performance were achieved. Using these principles, the MRL Corporation developed a general computer program which was used extensively in the UHS reconstitution effort.

The Byron UHS cooling tower test program was completed in 1987 and had as the main objective the determination of the tower characteristic, (Ref. 3). A total of 33 separate tests were completed, with varying wet bulb temperatures, water flow rates and heat loads. Simultaneous measurements of the air flow allowed for the relationship of air-to-water flow to be determined as well. The tower characteristic and air-water curve are required when predicting performance at conditions other than those directly measured. These Byron specific cooling tower functions were then incorporated into the MRL computer program by Environmental Systems Corporation.

Before using a computer program for safety-related applications it must first undergo a validation-verification process per CECo procedures. The validation plan utilized a hand calculation to independently verify the accuracy and reliability of the code (Ref. 23). The results of this comparison are documented in the validation report (Ref. 15).

The hand calculation used the MRL heat transfer model, together with the Byron UHS tower characteristic and air/water flow relationship. The only differences between the hand calculation and the computer program methodology were as follows:

1) The MRL program used a multi-point Simpson's Rule integration scheme to evaluate the demand integral; the hand calculation used the alternate method of Gaussian Quadrature to complete this task, and
2) The program used an iteration scheme to determine the sensible and latent heat transfers separately, instead of assuming fully saturated air upon entry into the tower, as was the case in the hand calculation.

A total of nineteen comparisons between the MRL program outputs and the hand calculations were made, (Ref. 9). The main parameters were varied over the following ranges:

- ambient wet bulb temperature: 50, 70 and 82 °F Twb
- water flow per cell: 6000, 8000, 10000 and 16500 gpm
- cooling tower range (ΔT): 4, 20, 23, 30, 38 and 40 °F

These broad parameter variations enveloped the conditions required for evaluation of the accident scenarios.

The level of agreement between the MRL program predictions and the hand calculations was shown to be very high. Values of the predicted cold water basin temperature agreed to within -0.40 to +0.02°F with an average difference of -0.09°F. Additionally, for all but three cases, the hand calculations yielded cold temperatures below those given by the program. The MRL program, then, as judged by the hand calculation, was seen to give conservatively high values of cold water temperatures over a wide spectrum of flows, cooling tower ranges and wet bulb temperatures.

In summary, this reanalysis of the performance testing of the Byron cooling towers confirms the results obtained in 1987. Therefore, the tower characteristic and resultant predicted performance remain unchanged from that given in the ESC test report (Ref. 3). Further, the successful validation of the Byron specific MRL computer program allows for its use at conditions specified by each accident scenario.

III. E. Time Dependent Basin Temperature Calculations

This calculation predicted the basin temperature using a time dependent two cooling towers model (Ref. 8). The basin temperature was the important result for it is the inlet temperature for the essential service water system. The calculations were performed using as an input, the scenario document which evaluated the various combinations of failures and plant initial conditions as described in Section III. A.

The time dependent feature of the model was developed to account for the transient nature of the LOCA heat load. The containment analysis as described in Section III. C. showed a LOCA Unit containment peak heat load of 830.8 MBTU/hr at 45 seconds and an average heat load of approximately 450 MBTU/hr for the first hour after the accident. At two hours into the LOCA the heat load has decreased to approximately 260 MBTU/hr and continued to decrease. The calculations used the time dependent total heat loads to determine the amount of heat added to the essential service water system.

The two cooling towers model was developed to provide the capability to model different flow and energy (heat load) going to each of the cooling towers. As discussed in Section III. B, the flow to each of the cooling towers could be significantly different under different accident scenarios. The model also had the ability to account for non-functional passive cells in a cooling tower. The fraction of flow to a tower was determined by dividing the flow to that tower by the total flows to both towers. The fraction of energy to a tower was determined by dividing the flow through the LOCA unit RCFCs that is going to that tower by the total flow through the LOCA unit RCFCs. Depending on the scenario, the energy transport also considered the distribution of miscellaneous heat loads. Cooling was assumed to occur only for cells with fans running at high speed.

The calculation used the following design inputs:

1. The accident scenarios and initial assumptions were as described in Section III. A.

2. The flows to the individual tower cells were determined by the Sargent & Lundy (Ref. 19 and 20). The flow data were developed based on the system alignments under different accident scenarios. The data was used to determine the amount of flow and energy going to each of the cooling towers.

3. The basin volume was assumed to be at the Technical Specification minimum of 50%, corresponding to an SX system inventory of 1,030,000 gallons (Reference 1).

4. The steady state heat loads of 31 MBTU/hr from the accident unit and 72 MBTU/hr for the other unit were used. These heat loads were from a Sargent & Lundy calculation (Ref. 13). These steady state heat loads were added to the LOCA Unit containment heat loads to obtain the total heat load on the UHS for the basin temperature calculation.

5. The LOCA energy profiles for various single failure modes were obtained from the calculation performed by CECo Nuclear Fuel Services Department (Ref. 14). This calculation included different cases which evaluated the effects of various combinations of available RCFC's/CS pumps or the loss of an emergency diesel generator. The calculation also included a case which provided a 'benchmark' of the UFSAR analysis. The calculated heat loads were approximately 25% higher for the first 2 hours than the heat load reported in Figure 9.2-7 of the Byron/Braidwood UFSAR. As an example, Figure 3 graphically represents the transient UHS Total Heat Load for scenarios where 4 RCFC's and 1 CS pump are removing heat from containment.

6. A wet bulb temperature of 82 °F was utilized for the majority of the analyses cases. For cool weather operation, a wet bulb temperature of 70 °F was used.

7. The cooling tower performance curves generated by the MRL computer program, as described in Section III. D, were based on the average flow per cell to a cooling tower. In all of the cases, the cooling tower performance curves were generated using a flow slightly higher than the average tower flow. This method gave a conservative estimate of the cooling tower performance since the tower performance increases with decreasing flow.

Thirty separate calculations (Ref. 10 and 24) were performed to evaluate the time dependent basin temperature responses. These calculations also included sensitivity runs to evaluate the effect of varying the fractions of flow and energy to the towers by + 10%. The results of the calculations verified the basin temperature does not exceed 98 °F under the postulated accident scenarios.

III. E. Time Dependent Basin Temperature Calculations (continued)

Several of the assumptions utilized in the calculations were inherently conservative. These conservatisms, while not being quantitatively analyzed, provide additional margin to the 100 °F SX system basin design temperature. Some of the major conservatisms are:

1. Basin level was assumed to be at the Tech Spec minimum of 50%. The basin is normally maintained at 82% level which would provide additional tower heat capacity.

2. No credit was taken for ambient heat dissipation in cooling tower passive cells (i.e. those cells with riser valves open but the fans off). Any cooling that occurs from these passive cells or from fans running in low speed would provide more margin to the maximum basin temperature determination.

3. The 80°F basin temperature calculations assumed 10 minutes for operator action to turn on the fans in high speed. The fans would typically be running in high speed earlier than the analysis assumed when started in accordance with emergency operating procedures.

4. No credit was taken for the cooling contribution from the makeup flow of the SX makeup system.

5. More fans than assumed are usually maintained functional.

It is certain that the calculated peak basin temperature would be lower if any of these conservatisms were removed.

IV. RESULTS/CONCLUSIONS

Introduction
This section summarizes the results and conclusions of the Design Basis Reconstitution program for the Byron Ultimate Heat Sink. The original concerns are discussed along with their resolutions as they were incorporated into the final calculations. Finally, the recommendations from Nuclear Engineering to Byron Station are addressed and itemized.

IV. A. UHS Operability Concerns

The UHS was designed for both normal operations and accident conditions such that the return temperature of the coolant supplied to essential loads would always be less than or equal to 100°F. A value of 98°F was used to maintain a 2°F margin to the 100°F SX system design temperature consistent with previous analyses. Questions relating to heat loads and flow and their potential impact on this limiting temperature ultimately resulted in an examination of the actual design basis of the UHS.

As delineated earlier in this report, the UHS is required to satisfactorily dissipate the heat loads from both units operating initially at 100% power, where one Unit experiences a LOCA/LOOP, and the other unit proceeds to an orderly shutdown. Concurrently, a single active failure is postulated to occur. These initial conditions, coupled with ambient weather conditions and operating requirements, established the starting point for evaluation of all other concerns.

The ability of the UHS cooling towers to satisfy the 98°F Technical Specification temperature limit receives it greatest challenge in summer weather when the wet bulb temperature can be relatively high. As the wet bulb temperature increases, the temperature to which water can be cooled by a cooling tower also increases. With the exception of bypass operation, which only occurs during cool weather, the value of 82°F was used for the limiting wet bulb temperature for all calculations.

The questions concerning SX flows to the cooling towers were resolved in a two step process. Starting from the accident scenarios, the status of equipment and overall system lineup was established. The benchmarked FLOSERIES model for the SX system was used to determine flows, in particular those directed to individual cells of each of the cooling towers. As mentioned earlier, the water flow through active tower cells is one of the main factors affecting tower performance.

The final items of concern were the magnitudes of the heat loads from both units. The postulated accident scenarios again were used to quantify these loads which were separated into two categories. First, the steady state loads from both units were determined by listing the individual loads of all components assumed to be in service. More significantly, the transient LOCA unit heat loads were re-evaluated for each scenario. The loads were then summed and incorporated into the final calculations.

IV. B. Results of Analysis

The ability of the UHS cooling towers to satisfy the design objective of maintaining a water return temperature of less than or equal to 98°F has been evaluated under normal and accident conditions. Of most concern was the tower response to a [illegible] basis accident. Accordingly, the majority of the reconstitution effort was directed toward examining a spectrum of postulated single failure scenarios.

The normal unit operating and shutdown loads are minimal when compared to accident heat loads. Therefore, under these conditions the UHS cooling towers have ample capacity to maintain the basin temperatures well below the Technical Specification limit of 98°F. At basin temperatures above 80°F the plant is required to have a minimum of six fans operating in high speed. Currently, an administrative limit of 88 °F is employed, above which shutdown is required.

The accidents which were evaluated were derived directly by application of from the system design bases. With one unit experiencing a simultaneous LOCA/LOOP and the other unit proceeding to a normal shutdown, four major accident scenarios were developed by postulating single active failures which could affect total heat loads and/or cooling tower capability. As allowed by Technical Specifications, two of the eight fans were assumed to be out of service. This condition reduces the overall tower capability. Two calculations for each of the scenarios were completed, one at an initial basin temperature of 80°F (no fans until 10 mintues), and the other at 88°F (fans automatically re-energize). Finally, the most challenging weather condition was assumed, that of an ambient wet bulb temperature of 82°F.

In summary, the results of the detailed calculations are as follows:

1. Failure of the Higher Capacity Containment Spray Pump
All other equipment was assumed to function properly. This case is of interest because it resulted in the highest peak heat load being supplied to the towers. The maximum basin temperature for this scenario was calculated to be 95.7°F.

2. Failure of a Cooling Tower Fan
This accident scenario was important to evaluate because of the resultant limited tower capability. Although it is known that some degree of cooling takes place in a passive cell, the calculations conservatively took no credit for such heat removal. Figure 4 depicts the resultant temperature profile for this scenario for the cases starting from initial basin temperatures of 80°F and 88°F. The maximum basin temperature was calculated to be 97°F for this scenario.

3. Failure of one Emergency Diesel Generator
This scenario resulted in the possibility of two failed tower fans. However, the accident heat loads were also significantly reduced due to the fact that only one train of RCFC's was removing heat from containment. Calculations for this scenario resulted in a maximum basin temperature of 96.2°F.

4. Failure of an Accident Unit SX Pump
The impact of overall reduced flow was evaluated in this scenario. Because tower performance generally increases with reduced flow, this accident was not as great a challenge to the UHS cooling towers. The maximum basin temperature was determined to be 95°F.

Based on the above calculations and results, it has been demonstrated that for all accident scenarios the basin temperature never exceeds the limiting Technical Specification Bases value of 98°F. Further, as discussed in Section III.E, several conservative assumptions were used, which if removed, would result in lower values of maximum basin temperatures.

In addition to the primary analysis cases, the effects of cool weather operational alignments were considered. The major change was that the ambient wet bulb temperature and the initial basin temperature were assumed to be 70°F consistent with the tower bypass valve interlock setpoint. The other major assumption is that if a bypass valve fails to close, there is a time delay of 30 minutes for local operator action. An example of the temperature profile for one scenario of bypass operation is shown in Figure 5. Maximum temperatures for the seven analyzed cases were all determined to be less than 91°F.

The analysis was expanded to include the effects of increased evaporation on the SX towers due to the increased heat loads. The analysis demonstrated that the existing SX make-up system can adequately maintain a water supply to the basins during a design basis LOCA under an adverse set of assumptions (Ref. 25). These assumptions include low river level, SSE, and single active failure.

IV. C. Operability Assessment Recommendations/Implementation

Nuclear Engineering Department made several recommendations to preserve the assumptions used in the analyses.

NED RECOMMENDATION	BYRON STATION IMPLEMENTING ACTION:
1. Maintain Riser Valve Closed when Fan is OOS	The OOS outage editor program and station operating procedure BOP SX-T2, "SX Tower Operation Guidelines", were revised to couple riser closing to a fan out-of-service.
2. Maintain Basin Temperature less than or equal to 88°F	Station abnormal operations procedures 1/2 BOA PRI-7, "Essential Service Water Malfunction" and UHS Tech Spec LCOAR procedure OBOS 7.5-1a were revised to incorporate the 88°F limit. Byron MCR Annunciator Response Procedures, BAR 1/2-2-B2, were revised for actions to control basin temperature.
3. At least six fans running in High Speed when Basin Temp > 80°F	Procedures 1/2 BOA PRI-7 and BAR 1/2-2-B2 provide actions to have ALL available fans running in high speed at >80°F. LCOAR procedure BOS 7.5-1a requires at least six fans operable at >80°F.
4. Maintain Basin Level at or above 50%	Byron Operating procedure OBOS 0.1-0, "Shiftly and Daily Operating Surveillance" maintains SX basin level above the 50% level (normally maintained at or above 82%). The Low Level alarm setpoint is at 56% basin level with auto makeup initiating at 53% level.
5. Start SX Fans in High Speed within 10 minutes of a Large Break LOCA	Byron Emergency Procedures 1/2 BEP-0 "Reactor Trip or Safety Injection Unit 1/2" (Temporary Change) contain actions to start all SX fans in high speed in the event containment pressure exceeds 20 psig. This is accomplished in accordance with Step 14 "Response Not Obtained" column to ensure the action is accomplished within the first 10 minutes. 20 psig in containment is indicative of either a large break LOCA or a Secondary Break. In both cases a large heat load would exist in containment so it is imperative that SX fans be started. Additionally, 1/2 BEP-1, "Loss of Reactor or Secondary Coolant Unit 1/2" (Temporary Change), addresses SX system operation during accidents other than a large break LOCA.

Additional station actions to support NED's Final Operability Assessment include:

1. Byron Station On-Site Review #91-172 was conducted to evaluate and accept the operability assessment.

2. Operating Dept. "Special Operating Order" #SO-U1/U2-18 explained the final resolution of the UHS issues until the Tech Spec Amendment is issued.

3. Byron Station Training Department issued a "Required Listening/Reading" package for all licensed operators explaining the resolution of the UHS items.

4. Byron Station Training and CECo Production Training Department were requested to review the On-Site Review and Operability Assessment to address potential changes or improvements in 1) Lesson Plans, 2) simulator modeling changes for SX operations, and 3) Simulator operator responses on large break LOCA's.

The administrative controls in place to implement recommended engineering actions provide reasonable assurance that the maximum basin temperature limit of 98°F will not be exceeded. The safety function and capability of the UHS, as assumed in the Tech Specs and UFSAR, remain unchanged. The UFSAR and Tech Spec changes required to clarify the UHS design and incorporate the administrative controls will be performed in accordance with Byron Station and Commonwealth Edison procedures including 10CFR50.59 reviews. A summary of the UHS UFSAR sections requiring significant revision is provided in Attachment B.

Attachment C contains a list of the remaining open items which require further evaluation.

V. **ATTACHMENTS**

Attachment A

References

1. "Byron Station Essential Service Water Cooling Tower Performance Test Program, January, 1989", Sargent & Lundy Letter to Mr. C.A. Moerke dated 1/19/89, File No. 917, (DFB-70), Project No. 7500-92.

2. Byron Special Procedure & SPP #91-008, "SX Pressure Flow Data", dated 5/3/91.

3. Environmental System Corp. (ESC) Test Report dated 1/22/88: Byron Nuclear Generating Station Essential Service Water Cooing Tower Thermal Performance Test Report.

4. Interim Operability Assessment Per ENC-QE-40.1 dated 4/15/91 (CHRON #166024).

5. Operability Assessment Per ENC-QE-40.1 dated 5/31/91 (CHRON #168014).

6. Calc. # NED-Q-MSD-2, dated 5/22/91: Operability Assessment of ESW cooling Towers per ENC-QE-40.1 dated 4/15/91.

7. Calc. # NED-Q-MSD-5, dated 5/31/91: ESW Cooling Tower Transient Model: Part II (Single Tower/One Basin Model)

8. Calc. # NED-Q-MSD-6, dated 9/3/91: ESW Cooling Tower Transient Model: Part III (Two Tower/One Basin Model)

9. Calc. # NED-M-MSD-8, dated 12/13/91: ESW Cooling Tower Performance Calculation: Part I, Rev. 1 (CHRON # 177488)

10. Calc. # NED-M-MSD-9, dated 10/24/91: Byron Ultimate Heat Sink Cooling Tower Basin Temperature Calculation. (Two Tower/One Basin Model) (CHRON # 174986)

11. Final Operability Assessment Per ENC QE-40.1, dated 11/1/91 (CHRON #175462)

12. Ultimate Heat Sink Design Basin LOCA Single Failure Scenarios, Sargent & Lundy calc. UHS-01, Rev. 2, dated 9/18/91. File No. 9.17, Project No. 8893-38/39.

13. Tabulation of UHS Heat Loads, Sargent & Lundy calc. UHS-02-Rev. O, dated 7/3/91. File No. 9.17, Project No. 8893-38/39.

14. Byron Station Containment Response for Ultimate Heat Sink Requirement, Commonwealth Edison Nuclear Fuel Services Department (CECo-NFS) document RSA-B-91-03, dated 8/28/91.

15. ESC/MRL Cooling Tower Performance Program VO1 Software Verification and Validation Report SVVR-805, Rev. 1, dated 11/91, CHRON # 177547.

16. American Society of Heating and Refrigeration Engineers (ASHRAE) Handbook fundamentals, 1989, IP edition, Pg. 24.7.

17. Sargent & Lundy Calculation UHS-04 "Ultimate Heat Sink Design Basis LOCA Single Failure Scenarios for Cool Weather Operation", Revision O dated 09-25-91.

18. Sargent & Lundy Calculation MAD-91-080 "Service Water Model Calibration", Revision 2 dated 10-04-91.

19. Sargent & Lundy Calculation MAD-91-121 "Cooling Tower Flows for UHS Analysis", Revision 1 dated 10-04-91.

20. Sargent & Lundy Calculation ATD-91-0142 "Cooling Tower Flows for UHS Cool Weather Analysis", Revision 1 dated 11-18-91.

21. "Commonwealth Edison Company Byron Station Nuclear Ultimate Heat Sink Studies", Westinghouse letter, CAE 91-221, B. Humphries (W) to R. Pleniewicz (CECo), August 8, 1991.

22. Lefevre, M.R., "Eliminating the Merkel Theory Approximations - Can it Replace the Empirical 'Temperature Correction Factor'?, "CTI Journal Vol. 8, No. 1, Page 36, dated February 7, 1984.

23. ESC/MRL Cooling Tower Performance Program Versions 01, Software Verification and Validation Plan SVVP-805, Rev. O dated 10/91 (CHRON #174759).

24. Calc. # NED-M-MSD-11, dated 12/17/91: Byron Ultimate Heat Sink Cooling Tower Basin Temperature Calculation (Bypass Operation) (CHRON #177615).

25. Calc. # NED-M-MSD-14, dated 1/9/92, Byron Ultimate Heat Sink Cooling Tower Basin Makeup Calculation (CHRON #178429)

Attachment B

SUMMARY OF SIGNIFICANT UHS UFSAR REVISIONS

Subsection	Summary of Revision
2.3.1.2.4BY	Revised to discuss the use of different wet-bulb temperatures in the SX Cooling Tower design.
9.2.5.1BY,	Revised for heat load values.
Table 9.2-6	Revised for heat load values.
Figure 9.2-7	Revised for heat load values.
9.2.5.2.1BY	Added new description for analysis assumptions.
9.2.5.3BY	Added paragraphs describing the new analysis. Renumbered the remaining paragraphs into a different subsection.

Attachment C

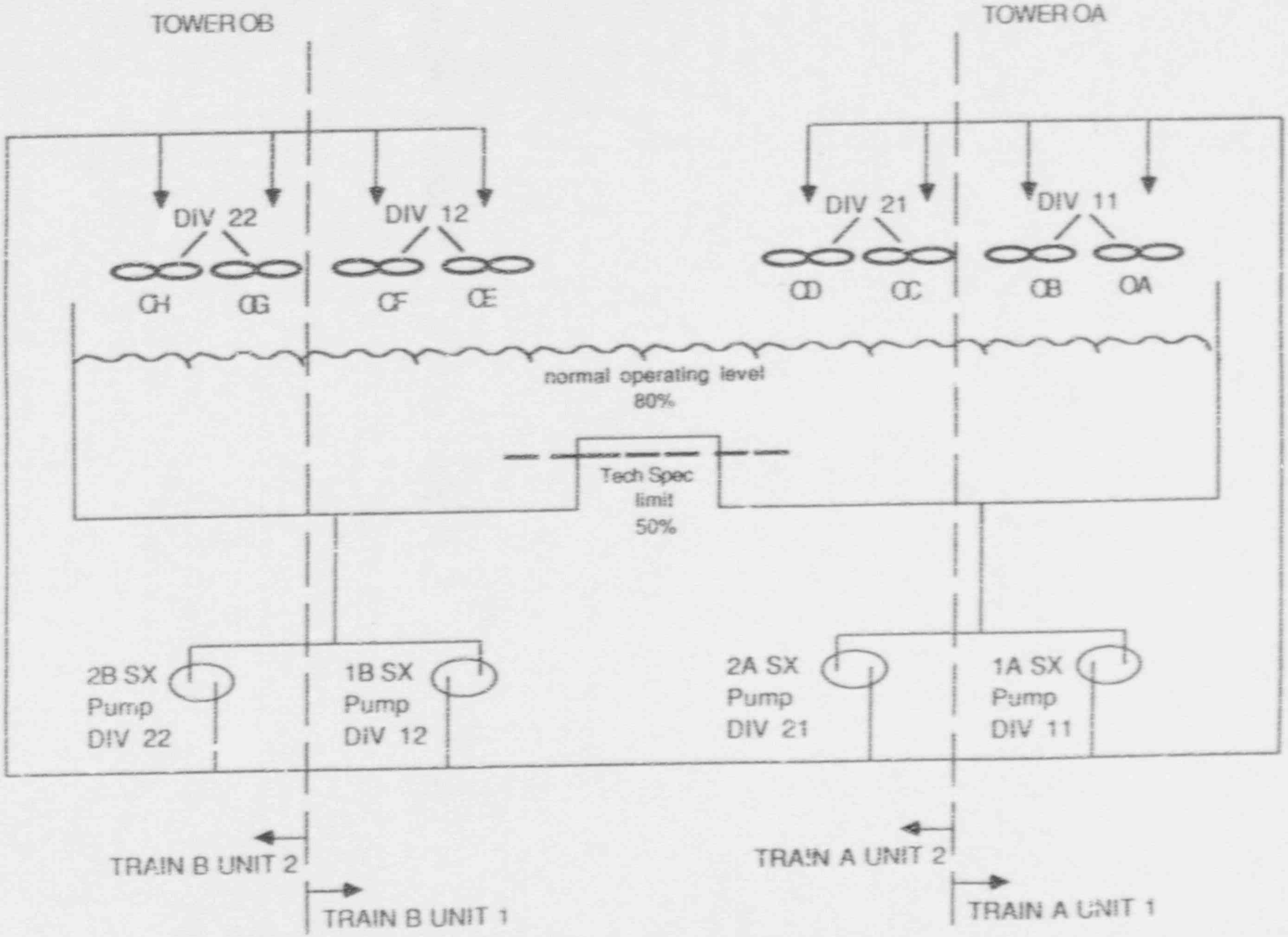
REMAINING OPEN ITEMS

OPEN ITEM	DESCRIPTION	COMPLETION DATE
UHS 91-01	Affect on other SX loads due to excessive CC Hx flows with only one SX pump running on the respective unit. An evaluation is presently underway to determine the maximum CC flow allowed such that other flows will not be affected. The analysis includes sensitivity of different flows to changing CC flows.	3/31/92
UHS 91-07	Braidwood analysis for Lake Evaporation A evaluation is underway to document the higher expected containment heat loads on the cooling lake in the Braidwood analysis.	3/31/92
UHS 91-11	"Station Blackout" impact on UHS A meeting has been scheduled to discuss and review the most recent analyses and its impact (if any) on CECo's committments to SBO issues	3/31/92

Attachment D

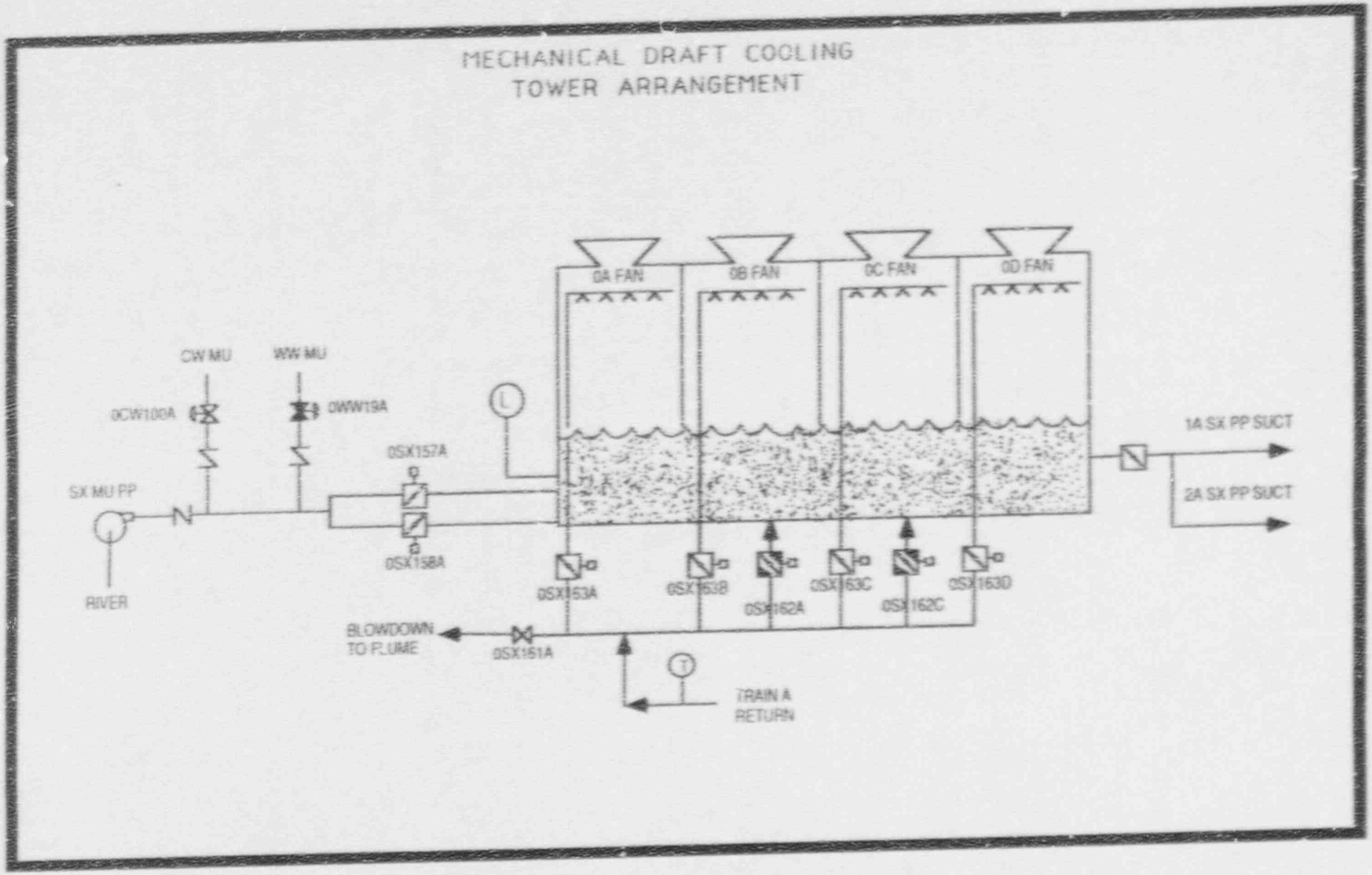
Figures

Figure 1



TOWER OB
TOWER OA
DIV 22
DIV 12
DIV 21
DIV 11
OH
OG
OF
OE
OD
OC
OB
OA
normal operating level
80%
Tech Spec
limit
50%
2B SX
Pump
DIV 22
1B SX
Pump
DIV 12
2A SX
Pump
DIV 21
1A SX
Pump
DIV 11
TRAIN B UNIT 2
TRAIN B UNIT 1
TRAIN A UNIT 2
TRAIN A UNIT 1

Figure 2


MECHANICAL DRAFT COOLING
TOWER ARRANGEMENT
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0B FAN
0C FAN
0D FAN
CW MU
WW MU
0CW100A
0WW19A
L
0SX157A
0SX158A
SX MU PP
RIVER
1A SX PP SUCT
2A SX PP SUCT
0SX153A
0SX163B
0SX162A
0SX163C
0SX162C
0SX163D
BLOWDOWN
TO FLUME
0SX161A
T
TRAIN A
RETURN

Figure 3
Byron UHS Total Heat Load
(4 RCFCs/1 CS pump)

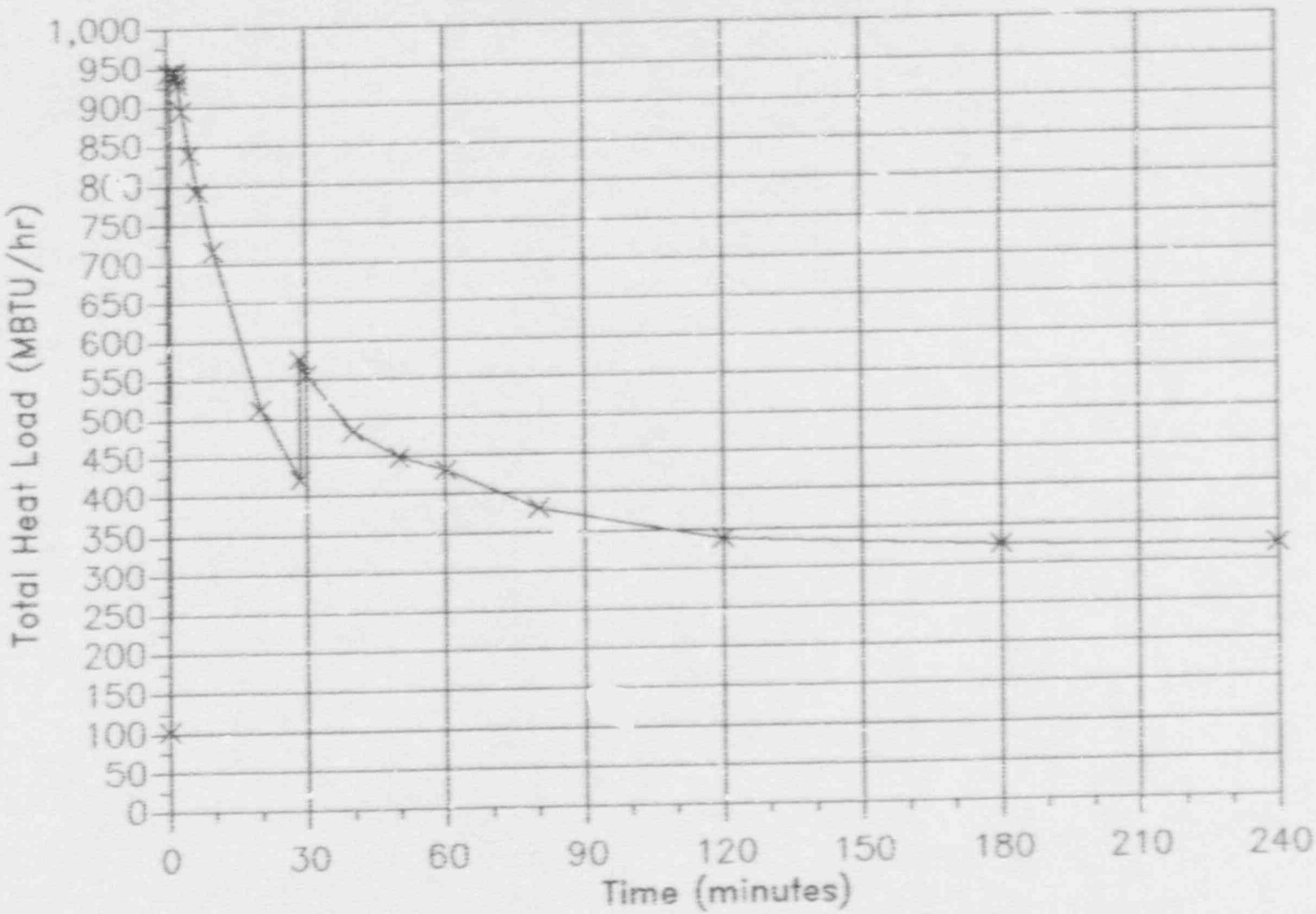

Figure 4
Byron UHS Cooling Tower Basin Temperature
Fan Failure Scenario

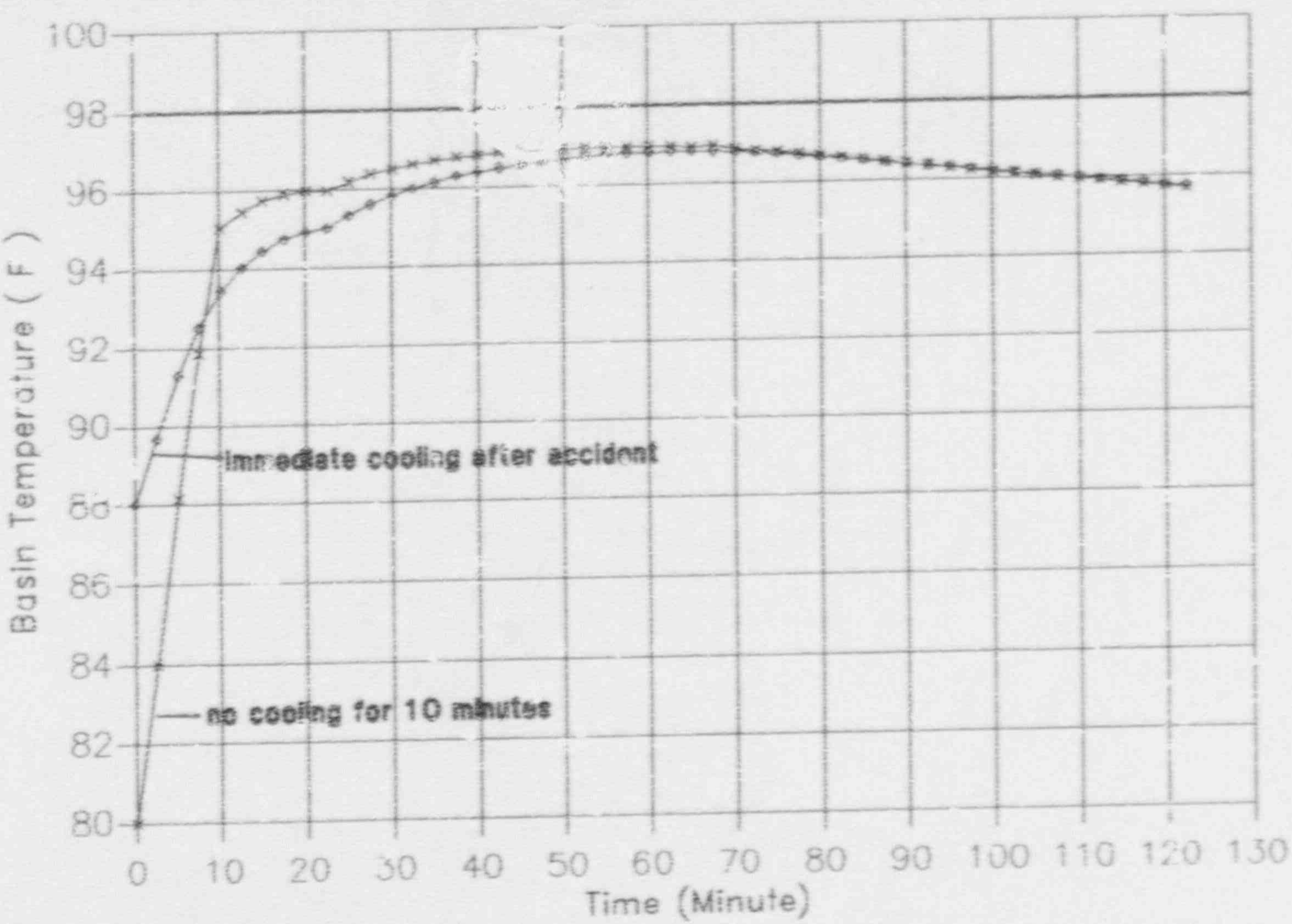

Figure 5
Byron UHS Cooling Tower Basin Temperature
Bypass Failure Scenario